ORNIA
CILITY

ENIGMAS
OF
NATURAL HISTORY

BY THE SAME AUTHOR

English Country.
The Common Earth.
Etc., Etc.

'But how if Nature vetoes all
Her commentators? Disenthral
Thy heart. Look round.'

From *Clarel*

HERMAN MELVILLE

ENIGMAS
OF
NATURAL HISTORY

By E L. Grant Watson

Illustrated by
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Introduction

The following sketches of animal histories are chosen from among the many examples of life in Nature which must evoke admiration, wonder and, I think, surprise in anyone who looks at all closely at the pattern they present. You may say that life itself must do this for most people, and that is true, but in these cases there are complications of development and association which particularly excite astonishment. In my choice I have avoided some of the most remarkable, as for example the histories of alternating generations in internal parasites. Such histories are to be found already printed in textbooks of biology, and I have not wished to repeat what is so easily accessible and what may be well known to many readers. The stories I have to tell are derived from papers published in scientific journals which are not easily accessible, and are also drawn from personal observations of animal life both in Europe and Australia.

In each case the creatures are described in their natural environment and are not, as in laboratory experiments, separated from it for the sake of either simplicity or elaboration. The animal, its form, its behaviour, its associates and its whole environment are regarded as comprising a unified and indivisible pattern, and any speculations I have allowed myself to make are the result of what feelings and thoughts this pattern evokes.

Such feelings and thoughts cannot, in any case, be ruled out, however much we may strive after objectivity. We see what we can, and what experience teaches us to see. Our surrounding universe is determined by what we have of poverty or riches in ourselves.

E. L. GRANT WATSON

Nine of these sketches have already appeared in THE NEW STATESMAN *to whose Editor acknowledgments are due.*

The Butterfly and The Ant

On the grass and thyme-covered cliffs of Devon and Cornwall and on the Cotswolds of Gloucestershire, there is still to be seen by those who look in the right time and in the right localities, one of our rarer English butterflies, The Large Blue (*Nomiades arion*). This little creature which is not so very much larger than the Common Blue, and would scarcely be noticed by any but an observant eye, has a life history of the strangest, and is so peculiarly adapted to the extravagant idiosyncrasies of its fate as to make any simple believer in the evolution of species through adapatation to environment pause and wonder.

The butterfly is to be seen flying during the last week in June and in July; it flutters close to the grass, like other members of its tribe, and the females can be seen depositing their minute eggs on the petals of the wild thyme flowers.

When the little caterpillar emerges from the egg it begins to feed on the downy exterior of the blossoms, and will in time work its way to the base of the petals. Besides its vegetable food it will readily devour any of its fellows that it may meet, and is at this period of its life voraciously cannibalistic. In shape it is like a wood-louse. Like all other caterpillars it must change its skin as it grows, and for the first two skin-changes it remains feeding on the flower-heads. After the third skin-casting the habit of the caterpillar changes. It becomes restless, drops off the flower-head and begins to walk. It has been described by Captain E. B. Purefoy, who has worked out the history of this insect with great exactitude, as walking as though it wanted something and did not know what. It walks and it walks until by chance it meets an ant. It is a remarkable fact that the eggs are usually laid by the mother insect on tufts of thyme that are growing upon ants' nests.

At the first meeting with the ant, the caterpillar shows no sign of recognising its future fate, but the ant recognises the caterpillar. She will begin at once to stroke and caress the caterpillar with her antennae and feet. Now on the tenth segment of the caterpillar there is a pore which has the power of secreting and exuding a sweet kind of honey-dew. As soon as the ant begins her caresses, the caterpillar exudes a drop of dew, which the ant sucks up. Other ants may come and join in this 'wooing' of the caterpillar, and subsequent milking. Many drops of dew are exuded.

After a time, prompted by some unexplained and mystic sympathy, the caterpillar prepares itself to be carried off. It gives the signal to the ant by assuming a most extraordinary attitude, swelling up the thoracic segments. The ant, on receiving this signal (and it is always the original ant that responds and not the late comers), gets well astride the caterpillar, and seizes it gently in its jaws, holding it immediately behind the hunched up thoracic segments. It then sets off at a quick pace, carrying the grub to its nest underground, and deposits it in one of the chambers where the young ant grubs are being nurtured.

From this time on the caterpillar lives on the defenceless, white ant grubs, and, in exchange for this hospitality, it gives to the ants its honey-dew, when with their antennae or their feet they caress the pore on the tenth segment. Experiments have been tried to stimulate this flow by other means than ant caresses. The pore has been gently tickled with the tip of a very fine paint brush. But no response has been made. Only to the touch of the ant is the insect sensitive.

All through the remaining weeks of the summer the caterpillar feeds on the ant larvae, and when autumn comes it hibernates in the underground cell, together with the ants. In the spring it wakes up again and recommences feeding. In late May or early June it will pupate. For three weeks it will rest in the chrysalis, and at the end of that time it emerges as a butterfly. Its wings are at first unexpanded, mere limp and shrivelled leaves that droop on each side of the body. How unlikely a place —the dark underground of an ant's nest for a butterfly to find itself. And how dangerous one would suppose, for ants will often devour butterflies, springing upon them and pulling them from the grass stems where they sometimes doze. But this butterfly, crumpled, helpless, deep within their own nest, the one-time devourer of their children, is free to crawl through the dark passages up towards the light. Why is it exempt? Why does it not perish? It possesses no longer any seductive honey-pore. Nothing that it can offer as a bribe for its exemption. It has a free passage as far as the ants are concerned, and if it does not lose its way in the dark passages, it wins at last to the light, crawls up a grass stem, and there begins that rhythmical pumping movement which fills the veins of the wings with its pale yellowish-green blood. They expand and hang over the back, folded together. In time the blood hardens, giving to the wings the necessary firmness.

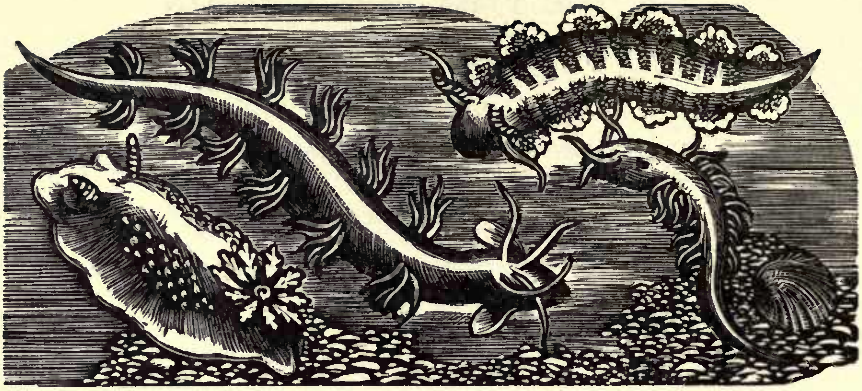
The life history is complete and the butterfly, who, we must presume, is quite unconscious of its cannibalistic childhood and its ant-devouring adolescence, now uncoils its long probocis preparatory to the innocent sipping of nectar.

How was such a creature evolved? Is it conceivable to imagine such a sequence of adaptations as the result of small continuous variations? Did the honey-pore spring into existence as a mutation? And if so, did the disposition to drop from the food plant and take to a wandering life synchronise with the origin of this mysterious organ? When did the first ant meet the first caterpillar? And did the first caterpillar hunch itself into a convenient shape, to allow the ant to carry it off without too much trouble, or were these habits learnt by practice and perfected through generations of experience? Why does the ant hold its hand, or rather its jaws, and spare the helpless butterfly that under other circumstances it would devour?

Are all these characteristics, so firmly established and so definite, to be explained by calling them fortuitous mutations?

Does that really mean anything? Will any of the Classical Theories of Evolution, Neo-Lamarckian or Neo-Darwinian, account for the strange sequence of facts in the life of the Large Blue?

W.N.H.



The Case of a Sea Slug

Sea slugs are brighter coloured and more fantastic in form than those that live upon land. They are to be found in shallow pools when the tide is low, and there are several species which frequent our English seaboard. Many of these have brilliantly coloured papillae or appendages growing from their backs, and in these are found groups of curiously formed stinging-cells, which are believed to function as defensive weapons, and which protect the slugs from the attacks of fishes. It is presumed that the fish snaps at the bright coloured appendages rather than at the more sober-hued vital portion of the mollusc, and that he receives in his mouth a discharge of nettle-cells which will send him away discomforted, and prevent further attack. This is true of only some fish, as there are species, such as the cod, which will devour sea slugs with impunity.

The nettle-cells, or nematocysts, as they are called, have a curious history, and one which might well provoke questions in the mind of any evolutionist who would maintain that the characteristics of living creatures are the results of environmental stimulus or of fortuitous mutations.

When nematocysts were first discovered to be present in the papillae of sea slugs, they at once excited the interest of scientists, for they suggested a definite and close affinity between the *Mollusca* and a more simple group of organisms, the *Coelenterata*, which include the sea anemones and jelly-fish. It was previously believed that only coelenterates were provided with nematocysts.

The nematocyst is an explosive cell, which, in its discharged condition, is usually of a long whip-like shape; in its undischarged condition it is folded within itself, and at the least touch, the turgor produced by the tension of the cell-wall will cause the enfolded nettle-lash to fly out and sting any foreign body which is in the near neighbourhood. Many sea anemones and jelly-fish are provided with these protective cells. Most people have at one time or another been stung by a jelly-fish, and though the nettle-cells in sea anemones are not so poisonous, their thousand-fold tiny barbs are to be felt by anyone who puts his finger in among the open tentacles of any of our seashore polyps. The barbs seem to cling to the skin and hold it. These nettle-cells are believed to be both protective and offensive. They would be, one could suppose, a protection against the attacks of sea slugs which feed upon the otherwise unprotected sea anemones; they also have an offensive function when helping to entangle or poison the prey of the polyps.

The facts of the relation between the coelenterates and the sea slugs, and the part that the stinging cells play in these almost miraculous happenings have been carefully worked out by marine biologists. It has been found that the nematocysts which lie in an unexploded condition in the papillae of the sea slugs, and which are used by them as defensive mechanism against their enemies, have their origin in the coelenterates on which the slugs feed.

Although this much is known, much still remains obscure. How is it that the nematocyst which explodes at the least touch, is *not* exploded by the sea slug in the process of being devoured? How is it that the harsh, saw-like radula of the slug, with which it *tears* its food, does not break the sensitive capsule of the nettle-cell? It has been suggested that the slug, in eating, exudes mucus which prevents the discharge of the nematocysts, but is this sufficient explanation? Why are not the defensive cells discharged on the approach of the slug? They are discharged in some cases, but not in all. Why not? And how is it that the slug is immune from the poison? Mr. O. C. Glaser writes: 'It is truly remarkable that these apparently helpless creatures (the sea slugs) should have selected such a dangerous prey, but since they have, it must be because the danger does not apply to them. Why it does not, I do not know, but it may well be that for the same reason the nematocyst does not discharge while being eaten.'

Those reasons, whatever they are, remain obscure.

The next mystery is: how is it that the unexploded, and only the unexploded nematocysts, are gathered together from out of the stomach of the slug into narrow ciliated channels, and are swept by the working of the cilia, extremely minute hair-like filaments, up into the tiny pouches which lie near the periphery of the brightly coloured appendages, and how is it that they are there neatly arranged the right way up, in such a manner that they can be discharged against any intruder which threatens the peace of the sea slug? How is such a complicated and highly specialised sequence of events to be accounted for?

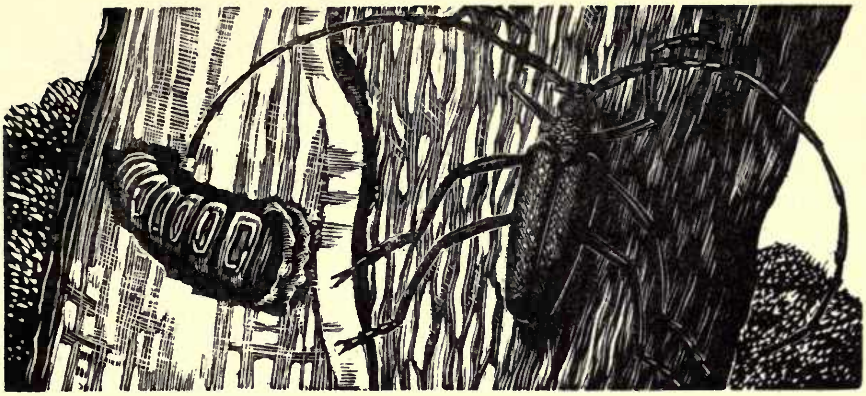
But is this really true? the reader will ask. Are you sure of the facts? Surely it is only reasoning, reasonable men who can steal the offensive weapons of weaker creatures to use for their own purposes!

The facts have been most laboriously investigated. G. H. Grosvenor has proved that the nematocysts found in sea slugs and coelenterates are identical in plan and construction and in mode of discharge, and that nematocysts of several distinct types occur in both groups—also that a single type of nematocyst does not occur uniformly throughout any one species of sea slug, but that different individuals of the same species may have quite different nematocysts according to the food. He has also proved that a single individual sea slug may have within the pouches on the dorsal appendages, nematocysts of several different types, found in distinct groups of coelenterates . . . and also that when it is known on what coelenterates a sea slug has been feeding, then the nematocysts in the two are identical. Also he has proved that sea slugs which feed on animals which have no nematocysts, have themselves no nematocysts. He has also demonstrated the ciliated canals which pass from the diverticula in the stomach to the pouches on the dorsal appendages, and he has conclusively proved that the nematocysts in any particular sea slug can be changed after a change of diet.

The facts are established, but the question of how this truly remarkable state of affairs has come about no one has answered, nor has any theorist tried to explain how any such unique combination of characteristics *comes to be evolved.*

When I was a student, Adam Sedgwick was professor of Zoology at Cambridge. On one occasion I remember when I was turning over the pages of a zoological textbook, he paused and stood behind me when I chanced to have turned up a picture of Archæopteryx, the winged and feathered reptile of the Triasic period. 'Precipitated!' he said with a characteristic sniff. I was then in my second year and a convinced Evolutionist. I turned to him with what might well have been an enquiring and discomforted look. 'Precipitated', he repeated. 'We don't say created in our days, it's not the fashion.'

It would need perhaps as wise a man to make the same comment after investigating the case of the sea slug.



Wise Worms

The larvae of a large number of beetles make their diet exclusively on wood. They live within the trunks of trees, and from the time when as small grubs they penetrated the bark, to the time when, two or three years later, they finally emerge as perfect beetles, they sense nothing of the world beyond the tree-stem through which they monotonously eat their way. If we could follow with an X-ray photograph the winding path of one of these beetle grubs, we would find that it began small, a mere thread, and that it gradually grew wider in diameter as the larva increased in size. The tunnel that the creature had made would be filled up in the track of the advancing grub with the wood-waste which had been excreated; this would be packed tight in one continuous line, filling all the tunnel. Little nourishment can be extracted from wood, and so the beetle larva is forced to eat most of his time. As there is nothing else to do, this is no great hardship.

The larva of the Great Capricorn Beetle spends the greater part of three years inside an oak tree. When it is full grown it is about two and a half inches long and five-eighths of an inch across at the thickest part of the thorax. It is an ivory white, and almost naked except for a few short hairs. It is a segmented, muscular tube with a mouth at one end, with gouging mandibles and strong muscles to drive them, an intestine and an anus. The true legs are vestigial, mere tiny, black excrescences, and are of no use in walking. The grub moves in its burrow by means of a number of four-sided facets, bristling with rough protuberances, which are placed both ventrally and dorsally on the segments. These are its ambulacra. When the larva wants to progress it expands its hinder ambulacra, both on back and belly and contracts the front ones. Having moved forward, it expands the forward ambulacra and contracts the hinder ones. It is only adapted for movement within the tube, and cannot move on a flat surface. This larva has no eyes, it is quite blind. It shows no sign of being able to hear. It is quite indifferent to smell. It can presumably taste its woody food, but can find little variety during its three years of oak diet. It is sensible to touch. Compared with the larvae of other insects which live in a less secluded retreat it appears strangely degenerate. The organs of sense are almost entirely lacking and the legs are mere vestiges.

It is not difficult to suppose that this creature has taken on its specialised and degenerate form in response to its environment; as the generations have passed, the senses, which were of no use within the dark silence of the tree, have degenerated, and the legs, designed in the first place to crawling over a surface, have withered and been replaced by the ambulacra on back and belly. This, on the face of it, is not an unreasonable supposition, but if we examine further the life habits of this grub, we will find qualities upon which its survival is altogether dependant and which it is hard to imagine as being derived from a purely mechanistic response to environment.

During the greater part of the larval life, the grub eats its winding passage through the hard heart of the oak; it never comes near to the surface of the bark, but keeps safely remote from woodpeckers and other insect-eating birds. If it were led by chance only, it would, in the long course of its twistings and turnings in that dark, silent burrow, be likely to come to the surface more than once. A guiding instinct keeps it safe, buried in the interior of the stem. When, however, the time draws near for the larva to change into its pupal state, it eats its way to the very margin of the bark, and will sometimes eat its way right through to the outside. This is its time of greatest danger, and it runs a very real risk of being eaten by a woodpecker. Why does it do this? For the good reason that the beetle, after the metamorphosis, is incapable of eating its way through hard wood. If the pupa were to be formed anywhere but at the extreme margin of the bark, the emerged beetle would die imprisoned.

The behaviour of the *senseless* grub in preparing for the pupal state is worth noticing. When it has eaten its way close to the bark, it makes a pupal-chamber three to four inches in length, about an inch wide and three-fifths of an inch deep.

The sides of this chamber it rasps with its mandibles, making a kind of velvety substance from the torn fibre, which will afford soft-lying for the tender pupa. Across the outward-pointing end of the cell it makes, from an excretion of its stomach, which hardens as it dries, a chalky shield, which serves as a protection to the otherwise unguarded end. Having made these preparations for the safety and comfort of the pupa, the grub, whose sole experience hitherto has been that of eating in a dark and silent tunnel, has the unvarying good sense to lay itself down with its head outwards towards the bark. The grub, which is soft and flexible, can, of course, turn easily in any direction within the cell, but the emerged beetle cannot move in any direction except that in which it lies. The beetle is encased in hard plates, and provided with stiff wing-cases, which cannot bend. Should the grub make a mistake and lie head inwards, the beetle, when its metamorphosis were completed, would be unable to turn round and would perish entombed within the cell. The grub never does make a mistake; it always lays itself down the right way, so that when the beetle emerges it has merely to push aside the chalky shield, which is easily dislodged from inside by its mandibles, and walk out into the world of sunshine which it can now see for the first time.

No one can imagine that this blind and deaf, worm-like grub can have any knowledge of its future life as a beetle; nor can it have any knowledge of the outside world. Is its behaviour the result of racial experience, and does this experience find its being and expression in the degenerate sense organs? Does the larva perceive, in its darkness and deafness and dumbness and scentlessness, which end of the cell is which, and so place itself, as the result of stimuli acting upon those sense memories? The thought is not unthinkable, though it is not one which easily commends itself as probable. If we follow this line of supposition, we must imagine earlier generations some of whom made mistakes, and who lay down for their pupal sleep with their heads in the wrong direction. On the law of chances, fifty per cent. would lie one way, fifty per cent. would lie the other. Fifty per cent. would perish, entombed and unable to emerge. Those which did emerge, we would have to suppose, would pass on a tendency to their offspring to lie down in the pupal chamber with their heads outward. And so in the course of numberless generations, so the argument must run, the inherited habit would become an unerring instinct in the grub. This thought, I repeat, is not unthinkable, and it affords a line of reasoning, which is held to be true by many biologists. The only alternative solution would be to postulate a life inspiration, a life wisdom, within the grub, which is innate and not acquired.

A Pessimist and an Optimist

There is a lady-bird which is greatly attracted by the scent of the nectar of flowers, and is so fashioned as to be unable to satisfy its desire to taste what its sense of smell proclaims as so attractive. This small beetle with its short legs and flat, tortoise-shaped body, climbs laboriously the stem of the flower-head, it negotiates the sepals, often in a difficult and upside-down position, and at length reaches the petals, at whose base the nectar lies. After taking up its position, grasping a petal, it puts its mouth in the direction of one of the honey cups which are situated on either side of the petal-base. Unfortunately for the lady-bird, it has but a short tongue, and one not adapted to thrusting into narrow places. In its effort to reach the nectar it bites with its mandibles. The petal falls off, and the beetle with it to the ground. Undeterred by this failure, it proceeds to creep up the flower-stem once again, and again makes its way on to a petal, again thrusts its head forward and bites, and again falls to the ground. Once more, after it has recovered from the shock of the fall, it hopefully repeats the process. The behaviour of this little lady-bird has been described by Dr. Herman Müller in *Die Befruchtung der Blumen durch Insekten.* It never learns by experience and never gets a taste of the sweet-smelling nectar.

If this lady-bird could formulate a philosophy from the results of its experience, it would be in agreement with Thomas Hardy, that 'life offers to deny'. The disharmonies between its desires and its means of gratifying them are obvious; it is a natural pessimist, a soul on whom Providence does not smile.

In contrast to such an unfortunate case there are creatures whose adaptation to their environment is so perfect and so complex that they would appear the very darlings of the gods, and to live in the best of all possible worlds. Not only are the details of their lives arranged with a happy and perfect precision, but they are endowed with a prophetic knowledge as to the needs and educational requirements of their unborn offspring, and are possessed also of an intuitive wisdom which can correctly determine problems before which our human science still falters.

Such a creature is *Eumenes Amedei*, a small wasp-like hymenopterian which inhabits northern Africa and southern Europe. In early summer when the sun heat is already powerful, the *Eumenes* emerges from the pupal state. She is an elegant insect of yellow and black bands. When stimulated by the sun's heat, her antennae, wings and legs are in vibrant motion, as though the life in her were too intense to be sustained without this quivering response to the elements of air and fire, of which she seems an embodied expression.

Soon after she has mated, the female begins to prepare a house in which her young can develop and be sheltered, and in which sufficient food can be stored. She chooses an exposed and sunny situation, usually on a rock or wall, and there begins to build. She first erects a circular fence of small stones and mortar, the mortar being made from dry, flinty dust mixed with her own saliva. The stones are chosen with considerable care, flint being preferred to limestone, and the fragments selected are all much of the same size. J. H. Fabre, in describing the habits of this insect, dwells on the meticulous manner in which the *Eumenes* chooses the most polished quartz fragments for her buildings, and suggests that she is not indifferent to the aesthetic effect of her handiwork.

As the wall grows higher, the builder slopes it towards the centre, and so makes the curve of a dome, which, when finished, is the size of a small cherry. A hole is left at the top, and on this is built a funnelled mouthpiece of cement. The next task is to collect the food-supply for the future grub, which is to hatch from the egg of the *Eumenes*. This consists of a collection of small caterpillars of about half an inch in length; these are always of the same kind, palish green and covered with white hairs. These caterpillars are partially paralysed by the sting of the *Eumenes* and unable to make any violent efforts at escape. They are stored on the floor of the cell. Since they remain alive, they will keep fresh till such time as the grub of the *Eumenes* is ready to eat them. If they were killed outright their flesh would soon become putrid or would wither and dry. The young grub requires the best of fresh meat. When the cell is sufficiently stocked, the egg is laid, a single egg in each cell, and the mouthpiece at the top of the cell is closed with a cement plug, and in the cement is set a single pebble.

The egg is not laid in amongst the caterpillars, nor upon one of them, as in the case of other allied genera. These caterpillars are only partially paralysed, and can still move their claws and can champ with their jaws. Should one of them feel the nibblings of a tiny grub it would doubtless writhe about, and would probably injure the tender infant for whose benefit all this genius of instinctive forethought is exercised. Both the egg and the grub must be protected, and to this end the egg is suspended to a tiny thread of silk fastened to the roof. However much the caterpillars may wriggle and writhe, they cannot come near it.

When the grub emerges from the egg, it devours its egg-shell, then spins for itself a tiny, silky, ribbon-sheath in which it is enfolded tail uppermost and with head hanging down. In this retreat it is suspended above the pile of living food. It can lower itself sufficiently far to nibble at the caterpillars. If they stir too violently, it can withdraw into its silken sheath, and wait awhile till the commotion has subsided, then later, when the caterpillars are grown quieter, descend again to its meal. As the grub grows in size and strength, it becomes bolder; the silken retreat is no longer required; it can venture down and live at its ease amongst what remains of the food store.

In all these ways, the *Eumenes* is singularly well adapted to the conditions of its life, but these are not all. The stone and cement cells that the mother *Eumenes* builds are not always stored with the same wealth of caterpillars. Some cells contain five caterpillars, and some ten. The females of the imago *Eumenes* are larger than the males, therefore they need a larger supply of food—in fact, just twice as much. From out of the well-stocked cells emerge females, from those half as well stored emerge the smaller males. Now the cells are stocked before the eggs are laid, and it is a generally accepted belief amongst biologists that the egg bears within itself the sex valency which will dominate in the developed creature. The maleness or femaleness of the egg is already determined at the time that it is laid. The female eggs are laid in the well-stocked cells, and the male eggs in less well-stocked cells. How does the *Eumenes* know the future sex of her egg? How is it that she never makes a mistake? Can a theory of chances play a part in this problem? If nothing is logically arranged, and all variations occur without any relation to a foreseen object, how is this clear and unerring adaptation to what is invisible and unmeasurable acquired? A question for behaviourists to answer.

Let us compare the fates of the *Eumenes* and the lady-bird. The one is endowed with the most perfect instincts for both building and hunting. The caterpillars on which she feeds her offspring are plentiful and easily paralysed, and obligingly remain alive until such time as they shall be eaten. Her grubs are endowed with a wisdom and caution equal to her own foresightedness, and over and above all this, the inspiration of her instinct tells her the future sex of her eggs, so that she may provide rightly and with economy for the needs of her sons and daughters. She lives in a world perfectly adapted to her gay, ruthless, vibrant nature. How different from the slow, tortoise-shaped lady-bird, whose appreciative senses tell her of the nectar she can never reach, and whose fate it is to fall clinging to the petal she herself has detached!

W.N.H.

Humble-Bees and their Doubles

The queen humble-bee, who is the builder and guardian of her household, and who is to become the mother of her own large family, is raised in her mother's nest in company with many other daughter queens in July or August. This rearing of the queens is the final effort of the parent colony, and as soon as the young queens are able to fly and are mated, they disperse and find for themselves suitable places for hibernation. They make small burrows in situations that are cool and dry, preferring a north aspect to a south, for they do not wish to be warmed into wakefulness too early in the following year. For eight or nine months they remain quiescent, and do not emerge much before mid-May.

The large black humble-bee with the red tail, *Bombex lapidarius*, is one of the commonest and most handsome of English bees; her life history, though it differs in details from that of other members of the genus, as she herself differs in physical appearance and size, is very much the same as that of all other humble-bees. As soon as she has come out from her winter retreat, she looks about for a nesting-place, and usually chooses the deserted nest of a field-mouse or vole. This is by preference underground or under a large stone or in a crevice of a loosely-built wall. Her first task is to arrange the moss and grass of the old nest into a spherical mass with a cavity left for herself in the centre, about an inch from side to side and of about five-eighths of an inch in height. On the floor of this cavity she deposits a lump of pollen-paste, that she has collected on the shanks of her hind legs. This she moistens with honey and fastens to the floor; it is to be the foundation of the cell in which her young will be enclosed, and is also to serve as their food-store. Around it, and above, she builds a wall of wax, and closes the cell as soon as she has laid her first batch of eggs. She now sits upon them night and day to warm them with her body, only leaving the nest to get food, and soon she builds a waxen honey-pot near the mouth of the nest, in such a position that she can reach forward and sip the honey while she is hatching the eggs or brooding her young.

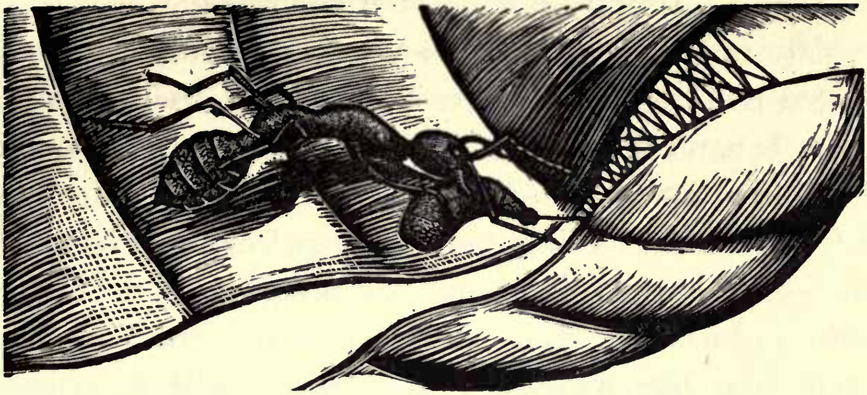
The eggs hatch into maggot-like, hairless larvae four days after they are laid. They are completely enclosed within the communal cell, in which they are free to mix together. For food they eat their bed of pollen and honey. As they grow older, the mother feeds them with a liquid of the same mixture which she injects through the wall of the cell. She also adds a thicker paste of pollen to the foundation. The grubs grow very rapidly, and, as they grow, the walls of the cell, which are always being added to, take on the shapes of the larvae which are contained within it. At seven days old they are full grown, and begin to spin their cocoons. These stand upright side by side, ten or twelve, or sometimes more in number. They do not form a flat-topped cluster, as might at first be supposed, but those at the sides stand higher than those in the middle, so that a median groove is formed. In this groove the mother bee can sit. She presses her body close to the cocoons to warm them, and stretches out her abdomen to its extreme length. Her outstretched legs clasp the cocoons on either side. Here she remains facing her honey-pot, and from time to time taking a sip to warm and strengthen her. After a period of rest, the larvae change to pupae, and on the twenty-second or twenty-third day after the eggs were laid, the young bees emerge. This first brood are all workers, considerably smaller than the queen. Like hive-bee workers they are capable of laying eggs, but these eggs will only produce drones.

For the first few hours these newly emerged bees nestle around the body of their mother. They are only about half her size, and seem indeed like children. They soon get to work however. Within three days they will be out and collecting pollen and honey with which to feed the new broods, which are already developing, for as soon as the first family of grubs are pupated, a further batch of eggs has been laid, and other batches follow at intervals of every two or three days. The workers now tend the growing families, and the original nest has to be enlarged to make room for the several batches of grubs. The queen, at this later stage of the family development, will often give up outdoor occupations such as collecting honey and pollen, and will remain altogether within the nest, attending to her maternal duties, and laying, at the height of the season, a batch of eggs a day. In July the queen will begin laying eggs which will produce drones and queens. The drones when they hatch are very similar in size and appearance to the workers. They have however a sweet and pungent scent, which it is supposed is agreeable to the queens. The young males leave the nest as soon as they are able to fly, and do not return. The young queens, although they may leave the nest for short flights, do not abandon it until they are mated. The old queen becomes less fertile as her days advance, she loses her hair and her wings are frayed and tattered. As the drones and the young queens depart, the workers dwindle, the comb becomes mouldy, and finally the queen dies. Her life history is completed.

Upon several species of humble-bees there are parasitic bees of almost identical appearance, and it is a remarkable fact that the parasitic species in each case should so closely resemble the creature that it exploits. There is some disagreement amongst authorities as to whether the *Psithyrus* is always parasitic and is not sometimes commensal, living in the nest of the *Bombi*, and contributing in some sort towards its welfare. However this may be in some uncertain cases, there appears to be no doubt that the species *Psithyrus rupestis* is definitely parasitic on *Bombex lapidarius*, whom she so closely resembles. The hind legs of the queen are hairy and are not adapted to the collecting of pollen, and the wings are slightly darker in the case of the *Psithyrus*. She is a slower flier, and the skin of the abdomen is much thicker and harder than that of the *Bombex*. The segments of the abdomen lap tightly over one another. In every other respect she would appear to be the double of her victim. So too does the *Psithyrus* resemble her host in every case where she lives in close association with a *Bombex*.

The *Psithyrus* queen enters the nest of her victims at about the time when the first batch of workers are emerging, or shortly after they have emerged. Her behaviour is, at first, inoffensive, and even deferential. Should she meet the *Bombex* queen, and the latter should threaten her, she will retreat, lifting a leg in protest, and will then hide in the nesting material. As time passes the workers cease to show any hostility and even the queen grows accustomed to her presence. Mr. F. W. L. Sladen, in his book on the humble-bee, gives a vivid account of how the disposition of the *Bombex* queen becomes affected by the presence of her enemy. 'The interest and pleasure in her brood seems less, and so depressed is she that one can fancy she has a presentiment of the fate that awaits her.' At the time when the *Psithyrus* is ready to lay her eggs, comes the crisis. It is then that the rival queens fight. The *Bombex* appears never to have any chance of victory over her better armed adversary. Her thin-skinned and less closely-jointed abdomen is pierced by the sting of the *Psithyrus*, she becomes paralysed and dies, and her dead body is torn in pieces. The victor now lays her eggs, and the grubs which result are fed and tended by the *Bombex* workers. Only drone and queen *Psithyrus* are produced; this genus has no need of workers, since the young grubs throughout their development are fed by the workers of their victims. It naturally follows that no young queen *Bombi* are ever produced in the nests infested by *Psithyrus rupestis*, and it is obvious that the *Bombex*, who is the original founder of the nest, and whose children are enslaved, is ruthlessly exploited by the usurper bee that so closely resembles her. Not only in the case of *lapidarius* and *rupestis* is this resemblance evident, but in every case where a *Bombex* is victimised by a *Psithyrus*. The latter are always slightly better armed both for offence and defence, so that the issue of the struggle is never in doubt.

Curious as is the close resemblance between the parasite and victim in each case, there is a yet more remarkable phenomenon presented by the presence of other insects which make their homes in the nests of the *Bombex*. At the base of each nest there accumulates a certain amount of rubbish, fragments of moss, and broken pieces of wax and spilt bee-bread. In amongst this rubbish, underneath the true nest, are usually to be found the larvae of hover-flies. These larvae do not do any harm to either the *Bombex* or the *Psithyrus*, who inhabit the space above their heads. They live their larval-lives of offal-eating, and complete their metamorphosis, emerging into typical hover-flies. The significant fact is, that these hover-flies mimic in the imago phase the species of *Bombex* in whose nest they have been commensal. Each species of hover-fly peculiar to each separate and differing species of *Bombex*, mimics that *Bombex*. I say mimics, but that probably is the wrong word. All we can safely say is: that whether it be *Bombex* species, *Psithyrus* species, or hover-fly species, all these living in the same nest have a close resemblance. It is as though some influence of the habitat or some influence of contiguity were at work, making these three different insects take on the same colour and form pattern. Is the *Bombex*, who is in the first place responsible for the nest, responsible for the influence which so affects the *Psithyrus* and the hover-fly?



Instinct and Intelligence

There is an ichneumon wasp whose maternal instinct bids it to seek for wood-boring grubs in which to lay its eggs. These grubs are boring larvae and live in the interior of trees. Sometimes they venture as near to the surface of the bark as an inch or three-quarters of an inch. They do not come to the surface, and there is no visible sign on the bark that they are lurking beneath. The ichneumon wasp knows, by some mysterious sense, where these grubs are located. With an unerring instinct she chooses the right spot, settles herself firmly with legs straddled, and bores with her long slender ovipositor into the hard wood of the tree. The ovipositor is but a hair's thickness, yet with this fragile instrument the insect is able to bore through an inch of wood and, what appears most wonderful, she chooses the one spot where she will find a grub in which to deposit her egg. By screwing and twisting movements this perforating operation is effected. It takes an hour of concentrated effort.

This creature offers an example of behaviour prompted by what has been called instinctive knowledge. Certainly the ichneumon behaves as if she knew that the grub was there and was vulnerable to the attack of her ovipositor. Whether she *knows* in any sense comparable to human knowledge it is impossible to say, though it would seem most probable that she is not conscious of what she does not see. All that we can say is, that she behaves as though she knew. Her actions, which are so perfect and precise, she does not learn from experience. The faculty is innate and adapted to her requirements.

Other examples of instinct which suggest a 'knowledge' which is beyond the function of intelligence are provided by certain Indian butterflies, which not only lay their eggs on the correct food-stuff, as most other butterflies and moths do, but which will not lay on any tree which is not frequented by a particular species of ants, which ants have the habit of tending the caterpillars of these butterflies and protecting them from enemies. The butterfly behaves, as already described in the first chapter, as if she knew that the caterpillars which will emerge from her eggs will be tended and cared for by the ants, and so selects the trees where the ants inhabit. It is almost impossible to believe that she has such conscious knowledge. As in the case of the ichneumon her behaviour is innate, and not acquired by experience, yet if we were to measure this behaviour by human values, we would have to assign to her both a zoological and botanical knowledge. The butterfly selects both the correct tree and the correct species of ants.

Major R. W. G. Hingston has described the above two examples and many others, in his fascinating book, *Problems of Instinct and Intelligence*, and although he admits that many insects are governed almost entirely by instinct, he contends that rudiments of intelligence, comparable to human intelligence, are to be found amongst ants, wasps, and other insects. Particularly he emphasises the intelligence of ants. Of ants there are a vast number of species, and the behaviour of each species is peculiar and elaborate; the examples chosen are from different species. The reader will judge for himself whether we have the right to apply the term intelligence to creatures which behave in such a manner.

A hunting ant, if she meets an insect such as a beetle, which is too big for her to capture alone, will grip it by a leg and endeavour to hold it down. Other ants will soon realise that a struggle is taking place and will hurry to assist their sister ant. They spread themselves round the beetle, and will seize on every projecting part, legs, antennae, wing-cases. They will pull at and stretch their victim in every direction. A few ants will gather to hold a small insect, and larger numbers for larger creatures. They continue to pull and stretch till their capture is dead. Next they have to transport their kill to the nest. This is done by a smaller number of ants than was needed for the killing. As many of these ants live in trees, the burden must be lifted. This lifting is effected by a larger number of ants dragging from above and a smaller number pushing, and directing from underneath. If human beings were to attempt a proportional task, they could not devise a better method.

Many ants find satisfaction in sipping the excretions of caterpillars, aphides and tree-bugs. They stroke these insects to excite the ejection of a drop of fluid, and it may justly be said that they milk them as human beings milk cows and goats. They guard these juice-producing insects as men guard cattle, they also herd them into special places, and sometimes into enclosures which they have built for them. Major Hingston describes how one particular species of ant will build sheds made of pieces of grass, interwoven with silk for the enclosure of their cattle, and he describes how once he found one of these sheds damaged and the cattle escaping. 'Four ants went after the stray-aways, got below them and cut them off. They probed them with their antennae, bit them with their jaws, by applying force compelled them to turn, then drove them with gentle prods back into the damaged shed. They got them in, guarded the opening, and later in the day repaired the hole.' Major Hingston contends that this behaviour was similar in kind to that which we attribute to intelligence amongst men. Other ants herd caterpillars into special reserves, and not only keep them there for milking, but drive them out to pasture every day. As an instance of another kind of intelligence, there are ants which prey on caterpillars, which defend themselves by emitting a liquid from their spines. In this case the liquid is offensive to the ants. As soon as the spine is touched the caterpillar emits the offensive fluid. The ant holds a bit of dry earth to the drop. The fluid is absorbed. The ant bites at the caterpillar. More fluid is emitted, and again it is mopped up. The actions are repeated until the caterpillar is exhausted and overpowered.

Certain tree-nesting ants make their nest of leaves whose edges have to be drawn together and then fastened. The edge of one leaf is gripped with the mandibles, the edge of the other by the hind legs. The ant pulls, and the leaves come together. If the leaves happen to diverge far apart, a row of ants will grip the two leaves where they are close together, and chains of ants, clinging to each other, will link the edges where a larger space intervenes. The pulling is done as by a tug-of-war team, in regular rhythm. As the leaves come together, the ants adjust themselves to the new conditions.

Now follows what is the most remarkable feature of this nest building, an action in which instinct and what, from analogy, would seem like intelligence, are merged. The leaves have to be sewn together. The mature ant has no silk, but the larval ant is provided with the power of producing a silken thread for the spinning of its cocoon. The ants seize on their larvae, and holding them in their mouths, carry them backwards and forwards between the leaf edges, and in this way sew the leaves together. In each case the larva co-operates with the ant, and bends its head to the leaf-edge as the ant lowers it into a convenient position. This work will continue for hours and days, and when one larva has used up all its silk, another is brought.

The behaviour of these ants in the building of their nest may certainly be compared with human intelligent behaviour, but what about the behaviour of the grub? If we are to complete the analogy with human actions, then we should have to suppose human beings engaged on a complicated mechanical construction, for the completion of which the assistance of new-born infants is necessary. These new-born infants, who have no knowledge or experience of the world, would have to co-operate with seeming intelligence. Is such a state of affairs conceivable? Is it conceivable that the ant grub has any intelligent co-operation? If the acts of the grub are instinctive, what precisely differentiates them from the acts of the adult ants? Can we indeed say so confidently, as does Major Hingston, that the ants behave with an intelligence comparable with human intelligence? Would it not be safer to hedge a little and merely say that they behave *as if* they were intelligent, and so remain uncommitted but vastly astonished at the mysterious and so-far unexplained phenomena of their activities.

Victims of Necessity

The aboriginal tribesmen of the upper reaches of the Murchison and Gascoyne rivers are thin-limbed, wiry little men, who live the nomadic life of hunters, roaming in their never-ceasing search for food over vast arid plateaus of malee and mulga scrub. The rivers in this part of north-west Australia, though they are marked on the maps, are for the greater portion of the year, and often for several years running, little more than dry ditches, with here and there pools of stagnant water. To these pools all the creatures of the neighbourhood, from the aboriginal inhabitants to the tiniest marsupial mice come to drink. They are the centres of life, and are only rivalled by the occasional water-holes of the upland plains, these latter are often little more than mere clefts in the rock, sometimes no more than a yard in width, but infinitely precious for the three or four inches of water, which even in the driest weather comes seeping from some hidden spring.

In this semi-desert region where the rainfall is so occasional and irregular as to be absent for as long as nine or twelve months, the plants and animals that survive have to adapt themselves to the strangest, often most uncomfortable-seeming manners of life. It would appear that the country has changed from what at one time must have been more congenial conditions, and that these animals and plants, through countless generations, have adapted themselves to the highly modified forms which persist to-day. In this desert country, they are the victims of their necessity, and are often transformed in the queerest manner from their more normal types, in order to be able to sustain life at all.

There are plants which put forth only a few, small, hairy leaves, which appear most insignificant, and would hardly be noticed by any but the practised eye of a native. Small as their growth is above the surface, they possess enormous roots, and although the leaves stretch but four inches above the soil, their roots are bigger than footballs, and are full of water, reservoirs to be drawn upon during the almost continuous dry weather. These are eagerly sought by the natives, and when found, dug up and split open. And there are plants which possess roots which are shaped like long strings of sausages, ten to eighteen feet long. These the natives will dig for, and hang them on trees, that the water that is stored in them may run out. By such means the native Australian can augment the small supply available from pools and water-holes.

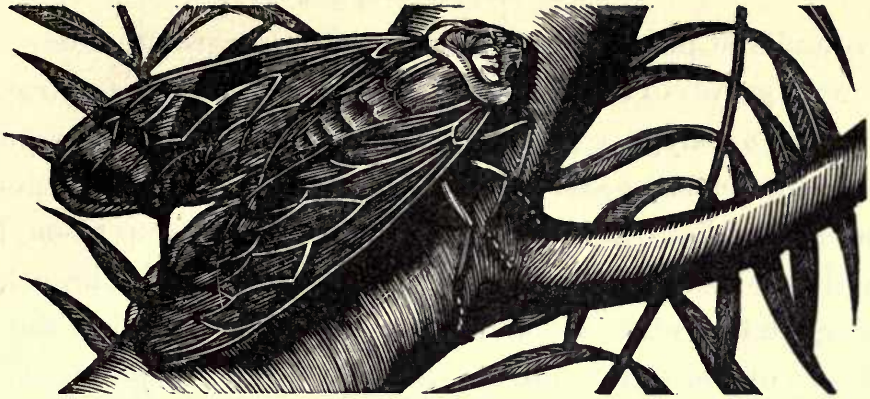
There are also animals which store water during the short moist periods, and are then compelled to hide in the ground, where they must wait till they are again released by another shower, six months or a year hence. A toad is an animal that one would not expect to meet in the middle of an arid, granite plain, for toads are creatures we are accustomed to finding in marshes or ponds, but there is a toad and a large one, a good six inches across, who is to be found on the upland plains of the Australian bush. This creature is indeed a victim of necessity, and is constrained to a completely passive existence for the greater portion of its life. When the rains fall, it comes out of its hole and rejoices for a short week or so. It mates and lays its eggs in the shallow puddles, it croaks all night long as though it were trying to pretend it was in a marsh, and then, as the rains cease and the pools begin to dry up, it fills itself to the fullest extent with water. It has specially developed lymph-sacs on each side of the body and encompassing the fore and hind limbs. These it fills to the uttermost of their inflation, so that it is swollen to twice its size; it then scratches itself a hole in the mud of the drying pool. This mud is, a few days later, sun-baked into hard soil, indistinguishable to any but the practised scent from any other portion of the dry, dusty earth. Here, baked-in, the toad must stay for months, living its own passive life, thinking its own imprisoned thoughts, and subsisting on the water stored in its body. It constitutes a small sphere of moisture under the surface, and only the highly developed sense of smell of an aborigine is able to scent it out.

I have seen young native girls and young women, sniffing the ground, and, at the right places, scratching with their digging-sticks, and unearthing the toads, who, when found, were ruthlessly squeezed of their moisture into expectant and, I hope, appreciative mouths.

Toads are not the only animals who store moisture. There are species of ants, living in the same dry regions, who store honey in their bodies, and this comes to much the same thing as storing water. Certain individuals amongst the ant community are selected to function as reservoirs. Cells are built for them deep underground, and, confined to these cells, they are pumped as full of honey as they can hold. The worker ants collect the honey during the short period when rain is falling and flowers are blooming; this they swallow into their own stomachs and carry to the honey ants. They bring it up out of their own stomachs and force it down the throats of the honey ants. The worker ant has an abdomen about the size of a small pea, but the honey ant's abdomen is often swollen to the size of a large grape. The skin is very thin and stretched and quite transparent, and the abdomen is distended to such an enormous extent that the ant is quite unable to walk. It lies in the seclusion of its cell, a mere living honey tank. When the dry weather comes and the flowers are all dried to powder, and no more honey is available, then, when the active members of the ant community are feeling the pangs of hunger and thirst, they come and tickle this helpless prisoner under the chin. It must then degurgitate part of the store, and so the community is fed.

The natives, who miss very little which is eatable in the bush, do not neglect the honey ants, which supply their one form of confectionery. The children dig for them, and hard work it is, for the cells in which these reservoir ants are confined are always placed deep in the earth, eighteen to twenty-four inches down in hard, dry soil. When the children find the ants, they bite off the luscious grape-shaped abdomens. This may seem a little barbarous and crude to people like ourselves who can so easily obtain ice-creams and chocolates, but where there is no sugar and very little honey to be come by, an inflated ant with a strong honey taste and a slight formic-acid flavouring is not to be despised.

There is another little creature who has gone to extreme lengths to adapt himself to the arid nature of his surroundings. A small lizard about six inches long has been given the rather pretentious name of Mountain Devil. This name is not given on account of size or wickedness, nor even on account of living in the mountains, for these lizards live equally well on the plains, where I have mostly met them; but they are named on account of their peculiar shape, which is all spines and sharp protrusions. If this lizard were sixty feet long instead of six inches, then he might be a devil worthy of his name, but he is an innocent and harmless little creature, who cannot even run fast, but walks at a slow, dignified pace. What is remarkable about him is that he does not need to drink. He lives in regions where there is no water, and he eats small black ants which contain very little of a soft or juicy nature under their chitinous shells. He gets his moisture through his skin. He catches the dew. For this reason it is necessary for him to have as large a skin area in proportion to his content as possible. The many spikes and protuberances give him this large skin area, and with this he catches the small dew which falls at night. The whole skin is absorbent, as can easily be demonstrated. While I was in the bush, I had three of these mountain devils tied to one of the guy-ropes of my tent, and often amused myself by putting a drop of water on one or other of their backs. The drop disappeared as if into blotting paper. This is how these little creatures drink. They need not seek for water or take it in at their mouths.



Sun-Worshippers

The Gascoyne river, which is shown large upon the map of western Australia, as though it were a considerable water course, is often for months on end a dry, gravel-strewn bed, with pools of stagnant water marking its course. The surrounding country in the neighbourhood of Carnarvon is arid steppe or semi-desert, and these pools, which survive, become, during the dry season, centres for animal and vegetable life. The stagnant waters contain fish of the most unexpected character, such as sharks and sword-fish. These sea monsters have come inland during the wet season when the river is full of water, and are now left to take their chance of life till the next rains. I have seen the snouts of sword-fish and saw-fish decorating the walls of farm houses a hundred and fifty miles inland. To these pools come all the animals in the neighbourhood to drink. Kangaroos, wallabies, boody-rats, bandicoots, and rats and mice are all to be seen creeping, in the twilight, out from the bushes that surround the pools. Besides the usual undergrowth there are frequent groves of tall gum-trees that mark the river's course.

The eucalyptus gums, which sometimes grow to great heights, are each possessed by their own groups of animal populations. One has but to lie in the shade and look up to see the tree-lizards clinging close to the smooth, sleek-barked branches. There are tree-mice also and birds of various kinds, but the insects are of course the most numerous . When the gums are in flower, and they do not flower every year but only occasionally, the pink and red blossoms are swarmed about, not only by all kinds and sizes of hymenopterans, but by many sun-flying beetles and butterflies. Huge buprestids whose bronze electra are two inches in length, and lesser ones of burnished green are to be seen high up, soaring around the flower heads. These most beautiful of all beetles are difficult to come at, as they only fly near the extreme tops of the branches. To collect them I have been forced to the vandalism of cutting down one of these magnificent trees. It came crashing to earth, and with its pink and red blossoms came many of the insects which were drinking their nectar. Not only on the flowers are creatures of interest to be found. There are hundreds of species which live under the loose folds of bark: gekko lizards of several kinds, centipedes of all shapes and sizes, some as long as nine inches, orange-coloured and dangerous, with a very poisonous bite, also scorpions, wood-lice and spiders galore, and hundreds of beetles, round as boot-buttons, from the size of a pin's head to a good inch in diameter, and numberless others of different shapes and kinds—all these are to be found under the bark. But the insects which are most noticeable of all, even more noticeable than the thousands of biting and stinging ants, are the cicadas. These fill the air with their tremendous song, so that the whole earth and all the air vibrates in response to their music. The greatest and the most beautiful of these is a brown, yellow and black insect of three full inches in length, and of four and a half inches across the expanded wings. This creature is as large as a small bird and flies as swiftly. On a hot day in the dry season there may well be several hundreds of them singing among the branches of one large tree.

The cicada is a drinker of the tree's sap. It has a sharp, sucking beak which it thrusts through the bark of the twigs down to the layer between bark and stem, and while it draws into itself the sweet sap of the tree, it sings. This singing is a harsh, jarring sound when heard close by, but when the insects are distant in the tree-tops and are pouring out that volume of unchecked ecstasy, then it seems that they are expressing in no ambiguous tones their appreciation for the sap they are imbibing, and their delight in the hot sunlight which gives them life. They create a continuous stream of sound which seems, while one listens, to form into a living curtain of gently varying notes, enfolding the tree, a curtain which blows to and fro with the moving gusts of air, and which is strangely expressive of the heat and the brilliance, which is so mildly tempered by the blue-green leaves of the eucalyptus. All through the hours of sunlight they feed and sing, and though many other insects respond to the sun and become torpid in shadow, the cicada, more than any other creature, appears both in shape and sound to be a direct expression of the sun's heat. Its body is of a dry, brittle consistence, and is full of air-spaces, these are resonators to the sound box, which is situated just posterior to the attachment of the hind pair of wings. By the opening and shutting of the doors of these resonators, the undulations of the song are produced.

When the Australian summer is at its hottest, the cicadas mate and lay their eggs high up on the terminal twigs. The female digs with her ovipositor under the bark, and tunnels a cell into which she will lay from six to ten eggs. Then she will pass a little way along the twig and repeat the process. She will lay as many as four hundred eggs—a large family to meet the many risks that must be encountered.

After a few weeks the eggs hatch. The larvae are at first queer fish-shaped creatures, with large eyes, and with their limbs contained in a sheath, which looks like a ventral fin. In this condition they wriggle up out of the cell through the hole left by the ovipositor of their mother. If their limbs were not enclosed in a sheath at this early stage, legs and antennae would become terribly entangled as they each struggled to get through the hole. They would never manage it. As it is, their legs are safe from entanglement and they can wriggle and slide over, and amongst one another, and so come to the open, though their hinder ends still remain caught in the hole and so prevent them from falling. The skin which has enfolded the larva during this emergent stage now splits, and the true larva struggles its way out, though it still remains held by its hinder end to the integument. It waits for a while, hardening its tender body in the sunshine; it kicks and tests its strength.

The subsequent larval phase is to be lived under the earth, and there is no future for these tiny, aerial fleas, that are born a hundred feet and more from the ground, unless they jump. Some mysterious impulse, which we call instinct, bids them jump and fling themselves into space. If they were to linger too long on the tree-tops they would wither and die. They must jump to live; and jump they do, and in their thousands. I have been under eucalyptus trees when these little, flea-like creatures have come showering down. They make a pattering and a rustling on the leaves. A great many must perish at this critical period, for they fall where the wind takes them. Some fall in the water and are drowned. Many are eaten by ants. Some fall on hard rock and wither and die. Those which survive crawl about and do not begin to burrow at once. It appears that there is a certain time ordained for exploration; they crawl at hazard over the earth in the same way that peacock caterpillars will crawl when full-fed before pupating. When they have walked far enough, and the straying instinct is satisfied, they begin to burrow and are soon lost to sight. The next four years are spent underground sucking the juices from roots.

When the full-fed larva emerges from the ground it climbs a suitable support. Here it takes a firm hold and clings until its thorax splits down the middle of the back, and the pale flesh of the emerging insect pushes its way between. The casket which contains the head cracks crosswise, and then, with slow, rhythmical pulsations the moistly-gleaming insect emerges. When it is free of the old case except for the tip of the abdomen which still remains fixed, the cicada turns over perpendicularly, head downwards, and draws itself out, then pulls itself upright once more, with the fore-legs hooked in the empty skin. The wings are heavy and moist, and the body is still pale in colour. The rhythmical pulsations continue and the wings are gradually expanded to the full size, being pumped full of the green blood, which soon drys and hardens within the veins. Within an hour the colour is darkened to the typical brown, yellow and black, and then at last, after four years in the earth, the cicada is free to enjoy its few weeks of air and sunshine. It spreads its wings in whirring, swift flight towards the tree-tops where hundreds of its kind are sucking the sweet juices and filling the air with their monotonous and all-pervading song.

On low bushes and on the stems of herbs are the empty skins of the larvae which have already experienced transformation. Sometimes as many as a hundred cling to one small bush. The dry, brittle, mud-stained cases still retain their shape though hollow of the insects that once filled them.

Sterility Corrected

When the pollen grains of any flowering plant, either blown by wind or carried by insects, come to rest on the sticky surface of the stigma, they soon begin to send out minute, delicately thrusting tubes, which find their way down the central cavity of the style, and at the base enter the matured ovules. The male generative nuclei pass down these tubes, enter the embryo-sacs and come into close contact with the ova and polar nuclei, thus effecting fertilisation. This is the normal procedure. The elongating pollen tubes do not usually meet with any difficulties in their passage down the style, even though the style may be of considerable length.

There are some flowers, however, in which the material of which the stigma is made is of such a texture as not to allow the pollen tubes to penetrate easily into the central cavities and thence to the ovules. In such cases fertilisation by pollination without the aid of some correcting or auxiliary factor is not possible. The yucca, of which several varieties are indigenous to both North and South America, is such a plant, and offers an interesting example of symbiotic relationship between itself and a small moth, by means of which the sterile condition is corrected.

The inflorescence of the yucca is a loosely branching spray of bell-like flowers; they are pale, pearly white, and like the evening primrose open at night and for one night only. These flowers are seldom capable of self-fertilisation, for the anthers are considerably shorter than the style, thus not allowing the pollen to approach to the stigma, and even should the pollen fall upon the stigma, fertilisation seldom follows unless the pollen is pressed far down into the central cavity between the three-fold division of the stigma.

Attendant upon these flowers is a small night-flying moth of the genus *Pronuba.* The species of *Pronuba* vary with different species of yucca, but the relation is always similar. *Pronuba* measures barely an inch across the upper wings, which are a shining white; the lower wings are grey. When the insect is in flight, it has a glimmering appearance, similar to that of our English ghost-swifts. It is peculiar in having the first joint of its maxillary palps elongated to an extraordinary extent and curved in a proboscis-like manner into a long tentacle. The inner surface of this is provided with stiff bristles. These tentacles, which can be coiled and uncoiled, are used for collecting pollen from the anthers of the yucca flowers. The pollen is worked into a ball, which is sometimes three times as large as the insect's head, and is carried under the head, and looks like an enormous crop.

The female moth alone collects the pollen, and only at such times as she is about to lay her eggs.

As soon as the female moth has collected a sufficiently large ball of pollen, she will select a freshly opened flower, and is careful to avoid flowers which have been open for some hours or have been pierced by other moths. She will then pierce the side of the style (which is the immature fruit) with the horny ovipositor with which she is provided. An egg is laid inside the style at the base of the ovules which there lie in rows side by side. As soon as the moth has laid her egg, she scuttles up to the top of the pistil and begins to stuff pollen from her ball into the cavity between the stigmas. When she has done this to her satisfaction, and she does it with considerable care and precision, she will either run down the style again and deposit another egg, or will fly off to another flower. In every case, as soon as she has laid her egg, she will hurry to the top of the pistil, and cram pollen down into the tube.

The result of this remarkable behaviour is that the pollen tubes can now find their way down to the ovules, and so fertilisation can take place. The ovules, with the exception of those which are placed in the immediate proximity of the eggs, develop into seeds. If those which are near the eggs were to grow and swell, the eggs would probably be crushed. After an interval of several days larvae emerge, and begin to feed on the growing seeds. They do not eat a great many, never more than a dozen in the course of their development, and since a large number of seeds are produced in each pod, sufficient are left for the autumnal distribution of seeds and reproduction of the plants.

The above are the facts of the strange relationship, which have been most carefully observed and recorded by Professor C. V. Riley and confirmed by Professor William Trelease. If it were not for the strange behaviour of the moth, and the no less strange modifications of its palps, which allow of the collecting of the ball of pollen, it would only be possible in rare and exceptional cases for the yucca plant to set its seed. If it were not for the existence of the yucca plant, the moth *Pronuba* would not be able to live, for it is only on the seeds of the yucca that the young larvae can feed. The two species, plant and moth, are mutually helpful to each other. The moth has developed the obliging habit of collecting pollen and stuffing it down the stigma tube of the yucca flower. The yucca has developed the habit of producing a sufficient number of seeds to satisfy the needs of the moth and leaving enough over for its own purposes. I have used the word *developed*, but is it possible to imagine the external circumstance which would prompt the moth to so strange a method of behaviour, or that would stimulate the development of so peculiar an organ as the tentacle on the maxillary palp? Are we not making a big assumption when we assume that the close-fitting pattern of fate, which is presented by the moth and the plant, is due either to environmental influences or to yet stranger and less accountable fortuitous mutations?

Is it not more honest to admit that our human reason, which is so much in love with a supposed relation between cause and effect, is staggered by the facts of this relationship?

Let us look at further facts which elaborate the surprising pattern. The yucca does not flower every year. Not only do individual plants take periods of rest between their years of inflorescence, but it often happens that all the yucca plants in a locality will flower in certain years, and will miss other years. There are years when no yucca plants are flowering in localities which cover a large area. What happens in those years to the *Pronuba* moths, which on emergence from the pupal state must mate and lay their eggs before they perish? There are no flowers with ripening ovules. The moths must die before the autumn, and with them not only their generation, but the whole species, since they will leave no descendants. After such a period there will surely be no *Pronuba* moths, and no seed will be set in the yucca flowers which at some later year will blossom.

If the moths emerged from the pupae and found no flowers, no doubt they and their eggs would perish, but on the years when the yuccas withhold their flowers, the *Pronuba* remain dormant in the chrysalis, and wait a time till the yuccas bloom. On the years when the yuccas bloom, the *Pronuba* is there ready to roll her balls of pollen.

That is easy enough to explain you may answer: The same climatic conditions which determine the flowering of the yucca may determine the emergence of the moths. But does that really explain the mystery? Is it not wiser to abandon all theories in the face of such strange facts, and admit only what is obvious, that there is a vital relation between the plant and the moth, whose intricate pattern we can observe, but whose origins still remain lost to us, and scarcely as yet guessed at.

Vital Affinities

There are hermit-crabs which have mysterious affinities with sea anemones. That the anemone establishes itself on the shell that the crab inhabits by a deliberate act, and not by mere chance, may be demonstrated in the following way. If a hermit-crab is confined in the same aquarium as an anemone which is already attached to a rock, the anemone will, after a short time, abandon its position and, gliding on its basal stalk towards the crab, will fasten itself on the shell. This guileless action makes no disguise of the relation between these two animals of such different structures, and which appear so far separated in their means of living. The hermit-crab is not merely passive in this association, as may be shown by detaching the anemone from the crab's shell. After an interval of a few seconds, the crab will pick it up in his claws, and pressing it against his shell, hold it there, till such time as the anemone has made itself fast once more.

It would appear from this that both creatures must find some advantage in juxtaposition to each other. How does the crab benefit? Perhaps he is concealed from his enemies by the presence of the polyp, or perhaps the creatures which prey upon him may dislike sea anemones and fear to touch their tentacles, which so often are armed with stinging cells. The anemone may benefit by the fact that the crab walks about from place to place and so produces a constant change of locality, with an increased chance of procuring food. Or again, when the crab is having a meal, fragments of his food may float up and be seized in the tentacles of the anemone. Such reasoning may appeal to a mind which demands easy explanations, or half-explanations, but when we come to investigate the vital affinities between other diverse pairs of creatures, we will find such ordinary and facile answers far from satisfying.

There are jelly-fish, creatures closely allied to the sea anemone, and also provided with stinging cells, which harbour within their stomachs small fish. These little fishes, much of the size of minnows, though of a more brilliant appearance, seem to have made of the jelly-fish a kind of living, transparent cave, a place of safe retreat, a house to fly to, and take refuge in when threatened by attack—and not only to be inhabited in times of danger, but on other occasions also. Often two or three little fish may be found within the jelly-fish's pouch, when the jelly-fish has been left stranded on the shore between tides. There is enough water in the pouch to keep the fish alive. When the tide returns the jelly-fish again floats, and the little fish emerge into the sea and swim around on their own, until such time as they may again wish to retreat.

There are several mysterious features about this relation. Why are the fish not stung by the nettle-cells of the medusa? How is it they are not digested, as other creatures are, by the juices in the pouch? Do the fishes retreat into the medusa only when threatened by foes who fear to approach within range of the powerful stinging cells which are active against most foreign bodies? Are the stinging cells inactive only against these favoured stomach-dwellers? Or are they active, and are the little fish immune from their poison? There is evidence to suggest that the cells are in some mysterious way made inactive. Another question is: Does the jelly-fish derive any advantage from the presence of the fish, or are they merely made use of? These are questions difficult to answer, and our imaginations are left open and wondering at this strange association.

I have myself witnessed another relation of a like nature, which left me at the time only half credulous of the witness of my eyes, for I did not then know of such strange partnerships. I was on the beach at Hayling Island. One of my children found a jelly-fish on the sand, a creature of about three inches in diameter, and apparently quite dead. I put it in a bucket of sea water, and we all had a look at it, and were delighted to see that it was alive, and was moving up and down in the bucket with a most graceful, pulsating rhythm. Inside its pouch were two or three little crustaceans of the nature of sand-hoppers. These were moving about inside the stomach, and I assured the children that the jelly-fish had eaten, and was in the process of digesting them. The children kept the jelly-fish to watch and play with it, and after a little came to me with the story that the sand-hoppers had got out of the jelly-fish and were swimming about in the bucket. I did not take much notice of this, and put down the escape of the sand-hoppers to the probably debilitated state of the jelly-fish. Later, when we went to bathe, I took the bucket and emptied it into the sea in shallow water about three feet deep. By this time the sand-hoppers were back again inside the jelly-fish. We all noticed this with great interest. It seemed to me curious that the jelly-fish, in that confined space of the bucket, could have recaptured the sand-hoppers. For the next fifteen minutes, I watched what happened as the jelly-fish swam leisurely and freely about in the shallow water. Some of the sand-hoppers came out and some remained inside. Those that came out swam about in the sea, but did not go into the sand, as I had expected. They returned after a swim of varying distance to the jelly-fish. There was one which went a good forty feet distant, and great was our surprise when it returned and entered the stomach of its all-obliging host, where it remained for a time resting. How could this tiny creature, after having strayed so far in the open sea, find again its own jelly-fish, who in the meanwhile had been drifting freely about? What land-marks or sea-marks could it possibly have? What was the strange affinity which drew it back to its drifting home? Neither my reason nor my imagination could find an answer; and when one comes to question how such a homing-sense could be evolved and maintained by any method of mechanical adaptation to environment, or by the chance mutations of unit-characters, or by chemical reaction, then both imagination and reasoning power are again inadequate in the presence of such facts, which are amply confirmed by other observers.

Another case of affinity is that between the shark and the pilot-fish. A pilot-fish is a small brightly-coloured fish which accompanies the shark and most often precedes him, as though smelling out the way. The shark follows obediently the movements of his little scout. He never attacks or hurts the pilot-fish, which may at times retreat inside the shark's mouth, and, according to some writers, is even safe to explore as far as his stomach, and return uninjured. So close is this association that the pilot-fish will jump into the air after a captured shark when it is being pulled up out of the sea.

W. H. Hudson in *A Naturalist in La Plata*, tells of the affinity that the puma of South America has for man. Although men may hunt the puma and offer it every kind of violence, the puma will never attack men, and will seldom defend itself against attack. It has a quite unaccountable friendliness towards men, and has been known on more than one occasion to stay all the night through, beside men who have been wounded or incapacitated, and are lying out defenceless on the pampas. The puma, on these occasions, has become a self-appointed guardian, and has fought with and driven off jaguars, who would doubtless, had it not been for the puma's presence, have killed and devoured the wounded men. Such behaviour remains beyond explanation, but it is no less or more wonderful than that of the fish and the medusa or the sand-hoppers and the jelly-fish on Hayling beach.

More Vital Affinities

Among the corals of the Great Barrier Reef there are to be found minute crabs which live in close association with certain species of the more finely branched corals. At an early age the young female crab settles in a position between two branchlets. An irritation is produced by its movements which influences the future growth of the coral, making the branches broaden, and as they grow upwards to unite laterally and to coalesce with each other and so form a spherical cage about the size of a hazel nut. The narrow crevice into which the crab has worked allows her hardly any movement except in one plane, thus the outward and inward current which the crab produces in the act of respiration has sufficient fixity of direction and continuity to secure a definite result, for this current is probably what determines the growth and shape of the coral chamber. Within this chamber the crab lives safely protected from the shocks and dangers of the external world. A sufficient number of apertures are left to allow for the in-going and out-going currents of water, and in these currents, small particles are borne to and fro, on which the crab can feed.

When the female crab first settles on the branchlet, she is very minute, with a carapace not much more than a millimetre in length. She first lives in a very small chamber formed between the growing branches, but soon this becomes too restricted, and she moves up into the cup which is already being formed by the coral branches themselves. Although the currents of water may have determined the lateral growth of the coral, it still remains unexplained why the branches grow together at the top of the little cage which before long encloses the crab, and in which she is imprisoned for the remainder of her life. Very few specimens of the males of this species of crab have been observed, they are extremely minute and can pass in and out of the small apertures left for the intake of water.

This crab in relation to the coral, whose growth it can control, and which it can persuade to enclose it in a safe refuge, is a creature, which, as we learn of its strange habitat, must evoke both our wonder and speculation. For its own ends it makes a house out of the living substances of other animals; here it lives shut off from the dangers of the outer world. At the price of this safety, it becomes a prisoner, incapable of ever making its escape.

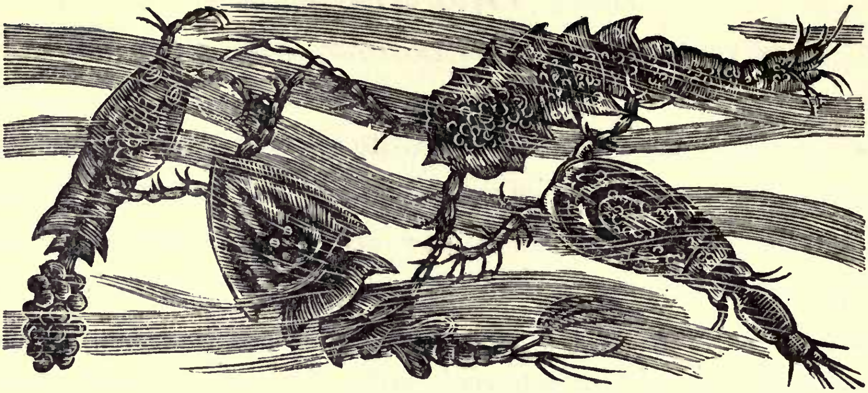
Henrik Steffens, a naturalist-philosopher of the early nineteenth century made the imaginative observation: 'Animals are fixed ideas incarnate.' The meaning of this statement is not patently obvious, but the contemplation of such life histories as have been described in this and previous chapters should help to reveal its significance.

There is another crab which frequents coral reefs and which has an interesting relation with certain small sea anemones. This crab is provided with claws or chelipeds of very small size, which are of little use for attack or defence. The fingers of these claws are armed with recurved teeth, enabling them to take firm hold on the slippery bodies of small anemones. With their claws, carefully and without injury, the crabs detach the anemones from their hold on the rocks. They then clasp the anemones, one in each claw, and hold them in close proximity to their mouths. The anemones do not appear to suffer from this rough treatment, and continue to spread their tentacles, and to capture any small creatures that are wafted to them in the water. The crab, with his first pair of walking legs, removes any tit-bit that he fancies from the tentacles of the anemone, and eats it himself. In this way his life is made easy for him through the functioning of a completely different species. He is seldom met without one or more anemones in his claws, and this association is developed in the species and not only in individual crabs. Whether the anemones derive any benefit from the partnership is very doubtful.

Another association between vastly different types of living organisms is that between the tree-sloths of South America and certain species of algae. Tree-sloths are mammals characterised by their short faces, rudimentary tails, shaggy coats, and hook-like claws, by which they hang back-downwards from the branches of the trees in the tropical forests in which they spend their lives. The most remarkable thing about them is that their hair is green. This green hair is much to their advantage since it makes them very difficult to see amongst the tufts of grey-green lichens among which they live. The hair is long and shaggy and is much coarser than most mammalian hair. If a section be taken of this hair, it is seen to be formed of two parts, an inner central portion and an outer sheath. This outer sheath is divided by a number of transverse cracks, and in these cracks there lives and flourishes a primitive plant, a one-celled alga.

In the damp, tropical forests, the algae in the cracks of the hairs find sufficient moisture, and by means of their green chloroplasts extract carbon dioxide from the air, and so increase and multiply. Their lives are by no means parasitic on the sloth, yet they find a safe harbourage in his long, coarse hairs, and by the green of their chloroplasts they bestow on him the true colour of vegetation. In this association, both species benefit, yet neither can be even remotely aware of the other.

The above description is of the three-toed sloth or aï. The two-toed sloth also inhabits the same tropical forests, and it is a remarkable fact that the hairs of this creature are of a different structure from that of the three-toed. The hairs in this case have no outer cortex, but are furrowed with longitudinal grooves. In these grooves live the cells of a different and distinct species of alga. The effect in both cases is the same, but the mechanism is different. The hairs in both species of sloth are long and shaggy and would seem to imitate tufts of lichen, so that the body of the sloth, as it hangs upside-down in the tree, would appear like a lichen-clad knot of wood. But only if these hairs are green is the protective device effective. Now it is assumed by evolutionists that the tree-sloths have been developed from some ancestral ground-living species. The question presents itself: Was the power of natural selection adequate to produce the shaggy, lichen-like hair in the arboreal sloths, and *at the same time* to produce the particular structures in the hairs themselves that allow of the association of the algae? Unless these characters occurred simultaneously they would each lose the greater part of their usefulness.



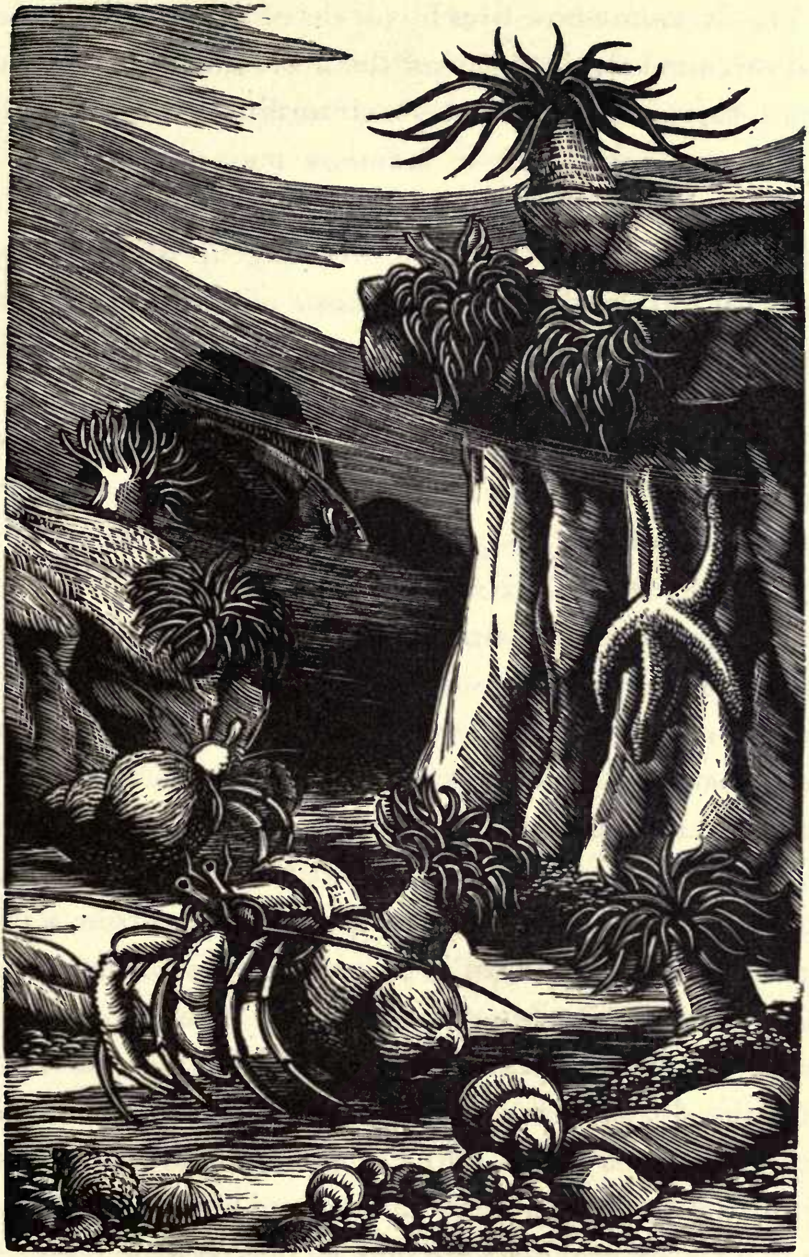
For Mere Life's Sake

When the larva of the common rock barnacle emerges from the egg, it is a tiny, free-swimming creature. It spends the first portion of its existence floating and swimming on the surface of the ocean together with millions of other small transparent larvae of akin species, amidst the vast host of all those other floating, transparent animals which live on or near the sea's surface. It grows and, as it grows, changes its form with each skin-change, until the time comes for it to take on a quite different habit of life. Then suddenly and at a single moult, it passes into a condition in which the body and limbs are enclosed in a bivalve shell. At this stage the first pair of its antennules project between the valves of the shell. On each of these antennules there is a sucker, by means of which the larva, after swimming about for a time, attaches itself to a stone or other object where it remains fixed for the rest of its life. A cementing substance is produced by a gland at the base of the antennules, which attaches the front part of the head firmly to the support. After a short time the first larval shell is cast off and replaced by the valves of the adult shell, in which the barnacle lives enclosed.

The barnacle and its allied genera are so unlike the normal types of crustaceans that for a long while they were classified as molluscs; only when the larval stages were studied, which are typically crustacean, were these sessile creatures recognised as being allied to jointed-legged, free-moving animals such as crabs, lobsters, wood-lice, etc. The barnacle is, as I have described, anchored by the head, and when we regard it as a specially modified crustacean, we see it as lying on its back, and kicking the food, which comes to it in the water, into its mouth by means of its long, oar-like legs. It may well be assumed that this creature has been produced by a process of development from the more normal type. It has become specialised to a sedentary life, and in the process has lost the normal characteristics, and has produced other peculiar structures which mask and disguise its origin.

There are other allied species which have gone further than the rock barnacle along this road of devolution. There are barnacles which are found only on the shells of turtles, and others which live attached to the bodies of whales, these latter are specially adapted to cling close to the moving surface of the skin; they suck folds of the whale's blubber into special cavities of their shells and so hold the tighter. There are other allied species which attach themselves to the bodies of sharks and dog-fish. In these a root-like process is developed from the head which not only serves as a means of attachment, but draws nourishment from the body of the host. And there are yet other species in which this process of devolution has gone further, to the most extreme lengths, where the parasite has lost all resemblance to type, and has become devoid of almost every characteristic which we associate with the life of animals. Such a creature is *Sacculina.*

The larva of *Sacculina,* which is a typical crustacean larva, swims freely in the sea till it attaches itself to some exposed portion of a crab, often one of the legs. Here, for a time, it clings on to a hair by means of its antennules. Its subsequent behaviour is most extraordinary. The larva bores through the cuticle at the base of the hair, and then the contents of its body passes into the interior of the crab as a formless mass of cells. The shell of the larva is left clinging to the crab's leg, and soon falls off. The mass of cells, which may now be regarded as the embryo of the parasite, is carried about in the blood-stream of the crab until it comes in contact with the underside of the intestine. Here it becomes attached. It grows, absorbing the juices of the crab, and it sends out root-like structures into the crab's tissue. In time it travels backwards along the intestine till it reaches the underside of the abdomen. Here it remains inside the crab until such time as the crab undergoes its next moult. After the moult a portion of the parasite protrudes externally in the form of a fleshy, sac-like mass on the underside of the abdomen. This fleshy mass is far removed both in appearance and structure, from the typical free-moving crustacean, and had it not been for the larva, no one would ever have suspected any relationship.



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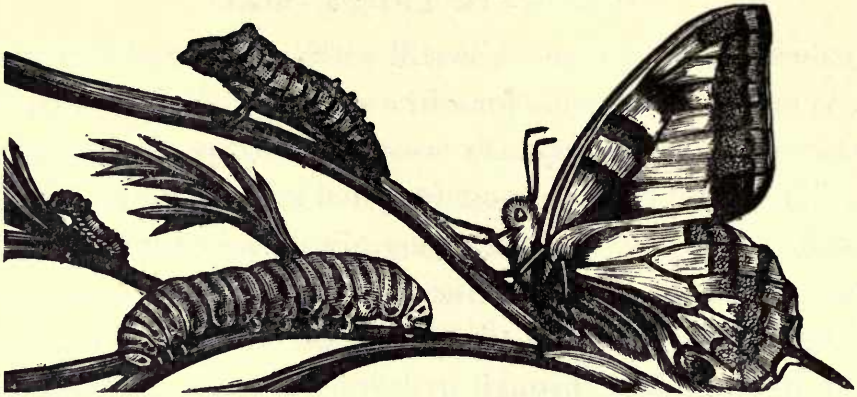
The *Sacculina* now lives by means of the root-like branches which surround the intestine of the host, and which take nourishment therefrom. How this extraordinary capacity to pass into the crab's body in a formless mass of cells has been achieved by the *Sacculina* remains a mystery, which can only be compared with that strange breaking up of tissues which takes place during the metamorphosis of such large classes of insects as the *Lepidoptera.* The question presents itself: What is the governing life principle which guides this formless mass of cells to its appointed end? And can the whole mysterious relationship be explained by mechanistic theories of chemical and physical reactions?

Another case of extreme modification is offered by an allied genus called *Thompsonia. Thompsonia* is found living parasitically on certain prawns and shrimps. Externally the parasite consists of a number of small, protruding sacs, sometimes as many as two hundred to a single host. When *Thompsonia* first came under observation, it was assumed that each of these sacs was a separate parasite, but Mr. F. A. Potts has now demonstrated that these sacs are all processes from a central root-system within the host. This root-system can be compared to the mycelium of a fungus, and in fact it might well be described as a mycelium, a thin thread, which winds most thickly around the dorsal nerve cords of the host, and which sends branching threads down into the muscles. Lateral roots pass out into the limbs and swimmerets, and it is on the ends of these that the external sacs are budded out. Within the sacs, the ova grow, mature and undergo their whole development. The eggs develop into larvae while still within the membrane of the sac. When they are ready for a free existence, the sacs burst, and the larvae, which are typically crustacean, escape into the sea.

This creature has almost forfeited its right to be called an animal. It is a mere thread, a mycelium, nourishing and producing a number of egg-bearing sacs. It has no senses, no organs save reproductive, and its affinities in the world of living things are only recognised through its larvae. It exists for mere life's sake, without hearing, sight, sense of smell or touch, and probably without even sensibility to pain. Degeneration could hardly go further, and yet this creature follows always the same general manner of weaving its mycelium about the dorsal nervous system of its host. There is an order and correspondence which does not vary beyond definitely set limits; the reproductive sacs are budded from the ends of the mycelium in crops, all appearing and ripening at the same time, and Mr. Potts suggests that this ripening of the sacs synchronises with those times that the host casts his skin. When the host casts his skin the sacs of *Thompsonia* are cast off with it. If the larvae were not ready for the free-swimming stage they would perish. In this fact there is an intimation that the life rhythms of the host and the parasite are in some unexplained way closely associated.



Transformations

The metamorphosis which takes place in the life cycle of insects, and especially that complete series of transformations within the life history of butterflies and moths, has been taken as a significant expression of the transformative processes of life. The essential differences in form, size and habit which separate the early phases of the larva from the perfect insect cannot fail to capture the attention of any observer, and to evoke the question: How can the transformations from larva to pupa, to imago, be reconciled with the concept of continuous transformations by innumerable, slow variations or with the concept of uninterrupted evolution by gradual functional changes; and further, how can the phenomenon of histolysis (the solution of the tissues) in the chrysalis, by which most of the organs are reduced to an amorphous emulsion, preparatory to the coming metamorphosis, be brought about by purely mechanistic, physico-chemical reactions? Is there not here revealed a testimony which declares that neither the changes in the larva nor the mysterious solution of the tissues in the chrysalis lead up to, or in any obvious way anticipate, the future morphology of the perfect insect; and, is not the conclusion unavoidable that this testimony reveals the existence of an ideal, proper to and working within the organisms in question? This ideal or 'final cause' being the determining factor which governs the transformations.

The process of such transformations can be observed in the life history of any butterfly or moth. In the following account, I have selected that of the swallow-tail butterfly, as one with which I have had opportunity of making myself familiar.

In June, or at the earliest the end of May, the first flight of the perfect insects takes place. In Wicken Fen in Cambridgeshire, and in various places in Norfolk, these butterflies are fairly common. They are very sensitive to weather conditions, and only fly on days when sun, wind and moisture are to their liking. By the end of June, the females are laying their eggs on the young leaves of the wild carrot, which grows most freely in the places where the sedge has been recently cut. These eggs are bright yellow and easy to see. Very soon, usually in about a week's time, the young caterpillars emerge. They are black with a tiny white band, and they sit on the ends of the leaf-fronds, making no attempt to conceal themselves. In a few days, they change their skins, or rather burst their way out of the skins with which they were first provided, and which are now too small for them. The new skin, which has been formed beneath the old one, looks on first emergence too large for the contained caterpillar, and so it is, for it is large enough to allow room for growth; and when the caterpillar has grown so that this skin in turn is stretched to full capacity, it splits, and the larva emerges with yet another new skin, which has grown beneath the old one. At these skin changes, the head, or rather the chitinous head-covering, is also shed, and if the larva is observed just before the change, the old head can be seen, sitting like a small hat upon the new, larger head which is beneath.

At the time of the change, the caterpillar will spin a small silk mat on which to fasten its claspers. Only when the claspers are firmly secured, is the caterpillar able to walk out of the old skin, and leave it fastened to the mat. It is usually fatal to the larva to move it from its mat at the time of skin changing, for if the hold is broken, and the caterpillar has entered into the quiescent stage which precedes the change, it is unable to make a new hold, and so unable to walk clear of the old covering, which remains tightly about it, and it dies. For this reason, it is a good plan, when collecting caterpillars, never to move them from their food-plant, but to pick the spray on which they are feeding.

At each skin change the young swallow-tail becomes more brightly marked. At the second change the white band is broader and has markings of orange and red. The full-fed larva is very conspicuous in stripes of yellowy-green and black with red tubercles on the black bands. If it is alarmed, it will bend its first few segments into an arch, and from between the second and third segment will produce pale, orange emergences, which look like tentacles, and at the same time a drop of pungent liquid will be extruded. This probably serves to warn any ill-advised bird that this creature, with its brilliant colours, will afford an unpleasant-tasting mouthful.

After thirty days from the emergence from the egg, the caterpillar is fully fed, and is ready for the change into the pupa stage. This readiness for change is announced by a restlessness and a desire to walk. When kept in captivity, there is no need for a hutch in which to confine these larvae; they will sit during the period of their growth peacefully on their food-plant; but at this later stage, they will leave the food-plant, and, if not shut up, will be found going at a full gallop all over the room. This activity is not produced by want of food, nor is it primarily a search for a good place to pupate. It is engendered by an inner restlessness, and seems to be undertaken for the sake of mere walking. In some species it is more marked than in the swallow-tail. The larvae of the peacock butterfly will walk a great distance at this time, and many caterpillars show signs of being ill at ease, and have a definitely sickly appearance, indicating that the changes of their coming metamorphosis are already at work within them. Their colour changes, and a marked shrinkage of size is noticeable. This walking-sickness, as it may well be called, fulfils the purpose of distributing the individual larvae over wide areas, and in natural conditions they are scattered far from the place where the parent insect deposited the eggs, and in gregarious caterpillars, such as those of the peacock and small tortoise-shell, this must be a definite help. In the breeding cage or in a room, the caterpillars will walk the destined number of yards, round and round and up and down, and will then begin the important business of preparing for the change.

In the case of the swallow-tail, the insects are now definitely smaller than when, full-fed, they began to walk, and of a yellower colour. The first act is to spin a firm, thick mat on which to fix the hind claspers. This is usually made on the dry stalk of a reed or blade of sedge. In an upright position, with the hind claspers fixed to the mat, the larva spins the band which is to hold the pupa in position. This difficult task involves much neck-bending. From side to side the head goes, while the fore feet guide and fasten the thread as far down the reed-stem as they can reach. This work is done slowly and with numerous rests. When it is completed, the caterpillar is circled round the back by a strong silk cord. It now rests facing the reed-stem and with the legs drawn close up under the head. During this period of rest the body shrinks and becomes noticeably smaller, and towards the later part of the time, all the claspers but the last pair release their hold on the reed, and the creature leans on its band of silk in a shape which is already suggestive of the pupa which is to be.

At the appointed time, usually after about fifty hours of quiescence, definite and rhythmical movements can be observed. These swell from the posterior to the anterior end and announce the immediate change from larva to pupa. These swellings and contractings become more marked until they become sufficiently violent to break the thin larval skin, which splits down the back, and a green, tender body seems definitely to push itself through the widening gap, and at the same time, the skin, as though pulled back by some invisible instruments, slips further and further towards the posterior end. It passes, in a way which appears quite miraculous, the silk cord, which one would expect to entangle it, and by what can only be described as the most extraordinary dexterity of wriggling, the now naked pupa works the skin down to the region of the hind claspers. As a penultimate act, it releases its hold on the silk mat, draws up the tail (it is now supported only by the silk cord, which looks perilously like slipping) lifts clear of the skin, pushes the skin aside, and finally fastens again on the mat, giving as a seal of its accomplishment a few quick turns to make secure its hold.

The empty skin falls, and the pupa now occupies the place of the larva, but it has not yet assumed the final pupal form. The posterior end is much rounder than it will soon become, and the part where the eyes and the head are to be is still snub and soft. This condition changes within twenty minutes, the chrysalis takes its final shape, and the outer integument hardens.

The shape and position of the organs of the butterfly which is to be, are already stamped on the pupa. It should be particularly noticed that these marks are on the *outside* and that there is nothing yet formed inside to correspond with them. This is a significant fact, and one which, when its significance is grasped, will modify the accepted idea that development takes place always, and only from a centre outwards. The governing ideal has at this stage at last declared itself, and although there is, within the creature, at this stage, nothing but a green watery pulp, all the places in its organism which are later to be occupied by legs, wings, antennae, etc., are now definitely marked. They are waiting to be filled by the organs, not yet made, but already determined.

The changes which go on within are no less and perhaps even more wonderful than those which have been visible from the outside. A breaking down of the tissues is taking place, and has been taking place for some time. Cells which are comparable to white blood-corpuscles are generated in large numbers at this time, and these devour most of the organs which have functioned in the caterpillar, reducing them to a kind of soup. These changes within the chrysalis are not altogether known, and even in their physical aspect remain very much of a mystery, but it is maintained that the tissues which are reduced by the phagocytes comprise the hypodermic cells of the first four segments, the breathing tubes, the muscles, the fatty-bodies and the peripheral nerves, and of these there remains no cellular elements. They are reduced to a non-cellular mush. At the same time as this change is taking place, the cells of the middle intestine assemble into a central mass. Later a new generation of tissue is formed, partly from this central intestinal magma, and partly from the proliferation of special corpuscles called image-bearing discs. Thus it is that the newly-formed portions seem to have no direct filiation with the destroyed parts of the larval organism. The creature has in fact died, in so far as it has lost its form, its organs and its habits, and now, in a manner which cannot be described as anything but mysterious, is experiencing a new orientation towards a quite different form, which is to find its expression in a quite different mode of life.

In this process of metamorphosis, it may be maintained that, we appear to be in the presence of the working of a concrete idea upon a plastic material. The idea of what the future insect is to be, impresses itself on a substance which has become non-structural and amorphous. If this statement is questioned, the questioner has but to look at the form impressed on the outer integument of the chrysalis, when as yet no organs are formed within it. What we have witnessed is the working of a centralising and directive force, which determines the chemical and physical reactions of the organic medium.

Although the changes which take place within the pupal case remain to a large extent obscure, the emergence of the butterfly can easily be observed, and is in itself a thing which will fill any observer with wonder. Caterpillars which have been brought up in captivity can be induced to pupate on convenient reed-stems, and these if kept out of the sun usually produce butterflies the following June. Unfortunately I have never been able to observe the pupae in their native habitat, for although the larvae and ova are easy to find, the pupae are very difficult to see, as their colour, which is green or grey-black, blends perfectly with their surroundings. It would be interesting to know whether the pupae at any stage in its metamorphosis is acceptable to the palate of birds, and whether it is for this reason that it is protectively coloured.

The emergence of the butterfly usually takes place between seven and eight in the morning. For some days previously the markings of the butterfly have been visible through the thin transparent shuck of the pupa. These markings, which on their first appearance are but faint, become darker daily, until on the last day the tone is mottled black, and yellow, these being the predominant colourings of the emerged insect.

The first sign that a change is about to take place is an expanding of the thoracic region. This is at first rhythmical and barely to be marked, but it soon becomes more violent and spasmodic, and before long the pupa-shuck splits down the back and across the shoulders. The internal swellings and contractings become still more marked, though often relieved with intervals of rest, and soon the broad, black back of the butterfly begins to push itself out and up; at the same time that this happens, the front of the pupa-case cracks in several places in the region of the legs and antennae. Soon the legs are thrust forth, the antennae are released and the trunk withdrawn from its sheath where it has lain. With an effort which now reaches its climax, the butterfly lifts itself on its newly-freed legs up on to the reed and draws the abdomen free of the case. Sometimes it will rest on the case itself, but more frequently on the reed. On its back are crumpled and misshapen masses, which are the wings, these are small, fleshy and thick, and give the creature, at this stage, a crippled appearance.

As soon as the insect has found a firm standing-ground, at the correct angle so that the wings can hang down over the back, it remains quite still except for the regular pumping movement, which is effected by a swelling and contracting of the thorax. By this movement the green, sap-like blood is pumped into the nervures of the wings, and thus gradually expands them. As the wings grow larger they fall back limply over the back, and, should they now by any mischance become injured, the blood will well out of the wound, and the wing fail to develop properly. If no such accident occurs, the pumping movement will continue until the wings are fully expanded, then it will cease, and the insect, now perfect, will remain quiescent while the blood within the nervures hardens and dries and becomes the stiff, resilient substance which is destined to take the weight of the creature when in flight. After about three-quarters of an hour's pause, the butterfly is ready to take the air, but usually it remains resting for a considerably longer time.

From the eggs which were laid in June a certain number of perfect insects emerge in August or September, but the larger number remain in the pupa during the winter and do not emerge till the following June. These specimens which emerge in August lay eggs and produce another brood of caterpillars. These pupate in September, and also pass the winter in the pupal state, to emerge in company with those which pupated earlier, consequently the June flight of butterflies is always the most numerous.

In this way the various metamorphoses of the life history are completed, and the 'final cause' of all that obscure yet definitely directed striving is completed.

Farmer's Friends and Foes

Every gardener knows what a nuisance field-mice can be when the time comes for the spring planting of peas. If once the mice find the row, they are likely to clear it, and even though the seeds are soaked in paraffin and rolled in lead oxide, the mice will have them, and leave the red, poisoned shucks on the surface for the gardener to mourn over. Mice do a great deal of harm, and not only by the eating of seeds and grain in the springtime, but by the raiding of humble-bees' nests in the summer.

Humble-bees, and how they live and rear their young have been described in an earlier chapter. They are insects which are very definitely useful to the farmer, for they help to fertilise the clover, and there are some kinds of clover, namely the Dutch Clover (*Trifolium repens*) and the Red Clover (*Trifolium pratense*), which are almost entirely fertilised by humble-bees. Experiments have been done to show that twenty heads of Dutch clover yielded 2290 seeds and twenty other heads that were protected from bees produced not one. The humble-bee then should be counted as one of the often unrecognised and humble friends of the farmer. For this reason the intelligent farmer will try to look after the welfare of his friends. He can best do this by bringing down the number of mice.

Now it has been calculated that field-mice destroy more than two-thirds of the humble-bees in England every year, and it has also been found that there are more humble-bees' nests near villages than in the open country, and this for the simple reason that there are cats in villages, and that cats eat mice. And so cats ought to be counted as friends of the farmer, and even the old spinster ladies who keep the cats ought not to be left out.

There are districts in Germany where a great deal of seed clover is grown, and here some of the farmers, the more intelligent of them, put up T-shaped perches about eight feet high and three feet wide along the sides of their fields. A stranger coming to the neighbourhood for the first time might well wonder what they are for. They are for the owls and the hawks to perch on. Owls and hawks eat an enormous number of mice, and the owl or the hawk can see the mice better if he has a perch about eight or ten feet off the ground. That is why the German farmers find it worth their while to put up the perches. And of course they would never be so foolish as to shoot an owl or a hawk, knowing as they do that the owls and hawks are among their best friends.

Some of my readers may think that the perch would not make so much difference, but a perch or vantage-point is used by any hunter, and one only has to keep one's eyes open to notice this. There is a table that stands out in my orchard at which we have meals in fine weather. This table is very much used by two cats who are great mouse hunters. I have again and again seen them spring down on to the mice and they never fail to make a catch. In the same way the perches are of use to the hawks and the owls.

While I am talking about owls, I cannot resist a protest against the way in which gamekeepers so often shoot these beautiful and useful birds. Owls, with the possible exception of the little owl, do far more good than harm. And particularly useful is the barn or white owl. This noble bird was far commoner in my youth than it is to-day, and the reason of its decline is that too few people know how very useful this bird is. The barn owl lives almost entirely on rats, mice, shrews, insects and sparrows. Often one can see them hunting the ricks in winter for roosting sparrows, or swooping on their silent wings close to ivy or evergreen bushes hunting the same prey. More than once I have seen a barn owl swallow a young rat whole; on each occasion the tail was left hanging from the mouth. For some time it remained there while the portion that was further down was being digested.

Another bird which should be numbered amongst the farmer's friends is the plover or pee-wit. These birds eat an enormous number of wireworms and there is no evidence that they ever attack crops. Every countryman knows that there are far more lapwings or green plovers in our fields in winter than in summer. They are great wanderers and come south from northern countries to these shores. A good deal of work has been done by naturalists to find out where these birds come from and where they go to. Birds have been caught and rings put on their legs with descriptive labels attached. Many birds ringed abroad are found here in winter, these are chiefly from Scandinavia and Germany. Young birds marked in England and Scotland are sometimes found close to their breeding ground; a large number remain at home, but others wander, and have been found in Ireland, France and Spain, and even as far as Africa. Very few of the English birds wander north.

When they are migrating they travel at great heights, often so high up that they are invisible from the ground. Airmen have observed flocks as high as six thousand five hundred feet. In the early spring and late autumn when the flocks are at their largest, the plovers will indulge in marvellous aerial manoeuvres, often mixing with gulls, jackdaws and rooks to make what is indeed a lovely sight against a background of high clouds. The plovers are always distinguishable by their quick turns and the swaying, changing flight. There are times when they rush earthward through the flocks of the other birds, and seem intent on dashing themselves against the ground. Only at the last moment do they swerve aside, and with their characteristic cry of pee-wit, begin to climb the air once more.

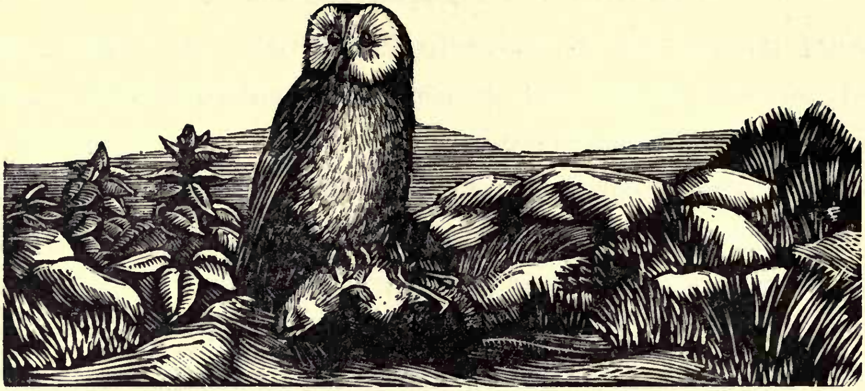
We all know their green mottled eggs, laid four in a clutch on the bare ground. These are protected by law, a law not so rigidly enforced as it should be, as a considerable traffic is still done in the eggs. These are birds that do only good to the farmer and have no bad habits.

Having mentioned some of the creatures which are friends to the farmer, I should not forget his foes. One of the most destructive of British birds is the magpie. He is intelligent and beautiful, but terribly bad for young ducks and young chickens, but especially does he love to eat up young ducklings and leave nothing to tell the tale of his early morning breakfast but their yellow feet. When the ducklings are small, he will polish off a whole brood at a time, and when they are older, even if they are too old to be killed and eaten, he will so peck at their necks that they will die soon after. The only way to protect the young birds is to have them under wire or to shut them in safely every night and not let them out till the farm hands are about. Otherwise the magpies come in the early dawn, and the young ducklings are no more. Magpies are also great egg eaters and all through the spring months they devour the eggs and young of other birds. All gamekeepers know how destructive jays and magpies are to pheasants' eggs.

Though magpies are very clever at avoiding the man with the gun, once they are caught, they are very easy to tame, and they make very attractive pets indeed. In the winter they gather together into quite large flocks, and in the spring these flocks become even larger, they form in fact what have been called marriage parties. They meet together for the purpose of choosing their mates. Sometimes as many as two hundred may be seen disputing and showing off, the males opening and closing their tails and raising and depressing their crests, and making themselves attractive to the female eye. They make short, buoyant flights and are indeed a beautiful sight to watch during these marriage meetings.

In northern countries where the winters are hard, magpies have been known, when pressed by hunger, to attack larger animals, and even men and women. Large flocks of them work together, and if there is a sore place on donkey or pony, they will attack it with their sharp beaks, and in a little while penetrate, as do the New Zealand sheep-killing parrots, to vital organs.

Among the smaller birds, the bullfinch is perhaps the most persistent enemy of man. This most beautiful and attractive bird is a real plague to fruit farmers and all gardeners. He has a springtime passion for salads, and as the only young green things then available are buds, buds he eats. There are some people who try to apologise for the bullfinch and say that he only eats worm-infected buds and that it isn't the bud he eats, but the worm. This is quite untrue. His attacks are deliberate, and he knows what he is about . He will perch on the stem, and will pick off one fruit bud after another, just tasting them and letting them drop. He prefers plum buds to pear buds, but when he has eaten all the plum buds he will show no hesitation about attacking the pears. And when he has eaten all the pear buds, he will turn his attention to the apples. It is rather difficult to understand why the bullfinch should be numbered amongst the wild birds that are protected by law when he is so exceptionally destructive, and when one bird can work in such a short time a devastation that brings to nought all the care of the fruit-farmer.



The Owl and the Beetle

The Little Owl is not a truly British species, but was introduced by Lord Milford some years ago from Holland. The first birds that were brought over were let loose on Wicken Fen in Cambridgeshire, and have since spread widely over England, and are now fairly common in most districts. It is not popular with gamekeepers or chicken-farmers, who accuse it of killing and eating young pheasants and chickens. Naturalists and bird-lovers have tried to make excuses for it, and tried to whitewash its character by pointing out that its diet is almost entirely composed of beetles and other insects. This argument in its favour, the owl does its best to support, for it has a habit, in common of other species of its kind, of bringing up a cast or pellet of the indigestible portion of its food. These pellets when they are collected and examined are found to be almost entirely made up of the broken wing-cases of beetles. There are no bones or feathers and often not much fur. 'And so', say the naturalists and the bird-lovers to the gamekeepers and the chicken-farmers, 'you are mistaken, these birds are innocent, they only eat insects.' 'But,' say the keepers, 'we know the little owl takes the young pheasants, because we've seen him do it, not once but often, and we have shot him too, with the young birds in his claws.' 'Yes and the same is true of young chickens', say the farmers. 'The owl's a nuisance, and it was a fool who ever brought it to England to be a plague to us.'

The bird-specialists answer: 'But he doesn't eat the birds, or he'd be bound to bring up the bones and the feathers in his casts.'

A close observation of the habits of the little owl have proved that both are right in their contentions. He does kill the young pheasants and chicks, but he doesn't eat them.

It was found by analysing the contents of the casts that these were made up, during the earlier part of the year, in April and May, of the remains of the harder parts of the burying beetle and of those beetles whose habit it is to live upon the dead bodies of animals. This gave the observers a clue, and they found that the little owl would search for the dead bodies of small animals, and seek under them, turning them over with its beak and claws, for the beetles which it finds so appetising. And not only that; it will regularly and systematically kill young birds and small animals such as mice and rats, and will carry the bodies to certain selected places, and will there leave them to become of the right sweetness of decomposition to attract the beetles.

After a day or two, this sagacious bird will return to his private collection, and will find his traps well stocked. All he has to do is to turn over the small corpses and find the beetles underneath.

These burying beetles are also interesting creatures, and can be best observed in April and May, when engaged in the task of burying the dead bodies in which their grubs are to find both habitation and food. The true burying beetle does not eat much of the corpse he is burying; he prepares it as a fit feeding ground for his young. He will bury it by working the ground away from underneath the corpse, and so letting the body fall into the space that he hollows out. The process is amazingly quick, provided the soil is suitably soft, and the little owls, if they are going to catch the beetles before they are too deeply buried, have to make frequent visits to their hunting grounds.

The question arises: Is this action of the little owl due to intelligence and reasoned deduction from facts, or is it the working of a complicated instinct whose origin remains obscure? It is worth while analysing what the process of reasoning would have to be, and examining the simple judgments which we will have to presuppose on the part of the owl. To begin with we may make the assumption that the owl likes the beetles. It finds the beetles that it likes best in the close proximity to the bodies of dead animals. So often does this experience occur that the association between dead bodies and beetles becomes established in its mind. Therefore when it wants to find the beetles that it most likes, it searches for the dead bodies of animals, and in this search for dead bodies it finds that they are not so frequent as it would wish.

So far, these associations of thought are fairly simple, but now comes a slightly more difficult one. It recognised the existence of live animals similar to those which it has found dead, and is able to make a definite and correct judgment as to the similarity. It then discovers, or it may be taught by the example of older birds, that it has the power of making a live animal into a dead one. But this newly-made dead animal has no beetles about it. The next step in the owl's reasoning is more difficult. It must recognise that a time interval is necessary, and must in some way or another come to the following conclusion: 'This dead body which I hold in my claws has no beetles in it now, but if I leave it in a suitable place which I can remember, and return to, it will in the course of time become rich in the beetles which I most like.' Such a reasoning must postulate on the part of the owl a sense of duration, also foresight and memory. This shows in fact a fairly high degree of intelligence as judged from a human standard. It is quite possible that the owl has such a standard of intelligence, and does go through steps of reasoning similar to those which have been indicated, but it is also possible that the determinants of its action are quite different from human determinants, and that it may be governed by an autonomous complex similar to those which are revealed in wholly instinctive creatures such as insects, of which examples have already been described.

Of Swallows and Starlings

Strange as it may seem, a large number of people do not distinguish between swallows, martins and swifts. These birds, although possessing considerable resemblances in their structure and flight, are quite easily distinguished. The swifts are completely black, are the largest of these species, and in flight the curve of their wings form the arc of a circle. The swallow has a blue back, and chestnut and blue breast bands, and long tail-streamers. The house-martin has a white rump and under parts, and a short tail. The sand-martin is a smaller bird than the house-martin and is brown above and white below. All these birds are often loosely grouped together as swallows, but with very little discrimination they can easily be told apart.

In the spring we all look eagerly for the coming of the first 'swallow', which is usually a house-martin, but, I think the late summer is the most interesting time to observe these birds. When the young house-martins have first learned to fly, the parent birds are divided in their activities by two conflicting instincts: one which prompts them to feed the young, which seem quite capable to feed themselves, but are too lazy, and the instinct to start new nests and to produce late, second broods.

Since both these instincts are very strong in them they are kept terribly busy. They swoop to and fro, collecting mouthfuls of flies, which they disgorge into the hungry beaks of their clamouring brood, and then rush back to the banks of pond or stream to gather mud to start new nests, then back to feed the young ones, and so it goes on all day. The new nests grow so slowly that often nothing comes of them, and it may be that this late-nesting instinct merely serves to prevent the parent birds from being over-solicitous for their full-grown children. These young birds are very reluctant to leave the nest, and when once they have left it, find it very difficult to get back again. Although the young martin can fly as soon as he takes the first desperate plunge, it is some time before he can use his legs and claws to any effect. He finds it very difficult to balance, and it is no small feat to fly gracefully up to a small aperture and cling to the lip of the nest as the parent-birds do. I have seen the young birds come up ten, twenty or thirty times, flutter near by, and yet not have the courage to make a plunge into the hole. When at last they do so, they often make a misshot, or else fall clumsily into the nest on their heads. Perhaps if the parent-birds were not diverted by their late nest-building, the young would be so well supplied with food, they would not venture out of the nest that they find so difficult to regain. And it is worth mentioning, that a large number of birds of various other species, once they have left the nest, never return to it.

The swifts or screechers, as they are usually called by country people, are one of the most interesting of English birds. They are so wonderfully modified for flight that they live almost entirely in the air, and their short legs are only adapted for clinging. Should a swift be mistaken enough to settle on the ground, it cannot rise again; it has to be able to let itself fall from a height to get sufficient play for its long, thin wings to feel the air. But once they have found it, how marvellously do they then fly! They do, indeed, scorn the earth or any traffic with it. At nesting time the females, like those of other birds, sit on their eggs, but it would appear that they are reluctant to perform this maternal duty. The males can often be seen and heard pursuing their wives with loud screechings, and driving them on to their nests.

After the hen birds are at last settled on the nests, the husbands consider themselves at liberty to disport themselves after their own fashion. They swoop and circle in the evening air, ever rising higher and higher, until at last they are lost to view, and only their cries sound faintly from the zenith. All night they fly to and fro, in wide-swooping curves, up there in the darkness. Perhaps they sleep on the wing, or perhaps merely drowse in a kind of airy stupor; whatever they do, they are following the instinct which drives them from the earth. There is evidence that they go very high indeed. I have never been fortunate enough to see them on their morning return to the earth, but W. H. Hudson gives an account of how at early dawn he saw a shepherd boy on the downs peering searchingly into the sky. He asked the lad what he was looking at, and the boy said he was watching to see the 'screechers' come down after their night's rest. This was the place they came down, he said, and he had often seen them come hurtling and screeching from the heights where they had spent the hours of darkness. Is it surprising that the human mind should have conceived of the martlet, the mythical bird that has no legs, that lives always in the air?

In the autumn, many of the young and the old birds which stay in England form into large flocks. Amongst the most noticeable of these are the starlings. Thousands of them are to be seen every evening gathering in reed-beds or copses, and these flocks get increasingly larger as more of the late hatched families come to join them. The gatherings of the starlings at sunset are among the most wonderful sights that the English countryside has to offer. The birds come in groups and parties from all quarters to join the main flock. Sometimes thirty or forty in a group, sometimes several hundreds. They come whizzing through the air at a tremendous pace, and when they have found the main population, they execute evolutions of wheelings and swoopings, in the larger, merged flock, and bend and turn their flight over the reed-beds, while still later comers join them. Sometimes they are like a vast, black ribbon drawn across the sky, then suddenly they will rush together to a centre, to re-form in outward moving patterns, the figure of some vast animal, then, like a wing of a bird, they spread out, and are lifted, till again at a sudden unseen signal, they are poured out like numberless black drops of water, and spread in a low-sweeping veil over the earth, to rise again and re-form, and again joined by others, continue their marvellous twilight dance, which expresses in so memorable and significant fashion the soul and essence of the flock.

I have stood watching, at one time and another, close under the rush of their wings for many hours, and while they have gathered for their night-roosting, I have both seen and felt the power of their collective being. They do not on these occasions appear as separate individuals, but all are swayed by the intuitive will of the species; every wing turns at the determined moment, yet they turn, not in precisely the same way, but with that slight difference, which makes for, and creates these marvellous, ever-changing and re-forming patterns, which result in such a surprising miracle of beauty.

At last they go down into the sedge, and the reeds bend and sway under their weight. There is a tremendous noise of chattering and scolding, which can be heard from a far distance, and often before they are settled, they will rise again, and circle and rush wildly to greet some late-comers, then again, like black drops pour themselves out on to the reeds, which are almost flattened by their weight. At last, a full hour later than their first gathering, they begin to settle down for the night. The chattering becomes less, the twilight darkens, and the last few birds drop down to roost. Slowly they become quieter and quieter.

Small Birds in Winter

When the winds of early December have stripped the trees of their leaves; the small birds, which escape notice in summer can then be more easily seen. Along the hedge-rows and in the copses there are large flocks of titmice; all the young birds of the summer's hatching are here with their parents, no longer in families, but forming the larger community of the flock, great-tits, cole-tits, blue-tits and marsh-tits, and sometimes, but not always, long-tailed-tits, or bottle-tits as they are sometimes called, are amongst them. These latter are one of the most beautiful of English birds, and well worth a close inspection. They have curious high-domed foreheads, flat faces with a Chinese expression about them, tiny, beady-black eyes, red eyelids and extravagantly long tails. Their body-colouring is of mauve, grey, white, pink and black, all blended in the most becoming fashion. Sometimes they form little flocks of their own, but never very large ones; they flit swiftly from tree to tree, uttering their shrill chirp of *zi, zi, zi.* They cling to twigs in any position, and for the most part hang swinging with their backs to the earth and their eyes on a level with their feet. Their black, thorn-like beaks are kept constantly probing for minute insects in the bark and under and amongst tufts of lichen. At each peck they must get little enough, and in hard winter weather when insects are scarce, it no doubt takes them a whole day of hard work to get sufficient food.

In company with the tits there are often golden-crested wrens, seldom more than one or two to each flock of tits, though I have seen as many as eight or ten together. Often one cannot see them, but can hear their unmistakable note. They are far commoner than is supposed, though they vary in numbers from year to year. A cold winter will work havoc among them, only a few surviving to the spring. In southern Kent and Sussex they are to be seen and heard in almost every copse; usually they appear in the company of tits, though they often linger behind when the main flock has gone by.

Goldcrests are extraordinarily tame, the tamest of all our wild birds, or it is perhaps truer to say, the most indifferent to the presence of man. They do not approach man in the same self-interested and comprehending spirit as does a robin, in the hope that his spade will turn up a worm, but in the same way as they might approach a tree, as a natural object neither to be feared nor avoided. I have had them within two feet of my hand; they have glanced at me from time to time and passed on, recognising that I was harmless but of no interest.

The flame-like crest on the males is very bright and easily seen. The feathers of this crest have the same metallic glitter as the feathers of humming-birds, and this is not the only feature they have in common with those tiny, brilliant honey-drinkers of South America. Like humming-birds they can hover, keeping their position in the air, and I have watched them hover with invisibly fast-beating wings opposite the underside of bramble leaves, on which no doubt lurked little groups of aphides. They are seen to their best advantage among a setting of bramble leaves, which in winter vary from dead-green to bronze and purple and saffron. They flit delicately amongst the brilliant colours, their own bright crests outshining by far the tints of the leaves.

I have often wondered where such small birds spend the long cold nights of winter. On very cold winters long-tailed-tits have been known to hibernate, some twenty or so together, and pressed into a feathery mass in a hollow branch. They do not usually do this, for they are nearly always to be seen flying about during the day-time. Goldcrests and the smaller tits often roost among the close-set, protecting needles of fir trees, and I have been interested to see how many different sorts of small birds sheltered in haystacks.

There is a large stack not far from my home that stands beside a tiled outhouse, on the roof of which a great number of sparrows, green-finches, chaffinches and other small birds gather every evening and carry on a very loud conversation about the adventures of the day. There are usually some hundreds all talking at once, and very cheerful and happy. I have watched them, and have noticed how from time to time some of their number would fly across to the stack and disappear under its eaves. Yet the gathering on the roof did not apparently get less; other late arrivals joined-up, and others gathered on the ash tree that stands near by. And I have seen a rival meeting of tits of all kinds, with a few hedge-sparrows and goldcrests, in the low-growing brambles and long grasses that are still standing. These also in their turn flew into the stack and disappeared. I have waited till dark, watching them, till they were all abed, and the last good-night twitter had been sounded. On some nights there must have been several hundred birds in that one stack.

A few nights ago I was watching a barn owl fluttering in its silent and ghostly manner over a ploughed field. The flight of these birds always fascinates me. The broad wings are so silent, and beat the air so gently, that it is as though one could feel the softness of the feathers as they pass. I followed him for some distance as he worked to and fro over the field. He did not find anything to pounce on, and after a time he set off for a neighbouring group of haystacks, not my own particular haystack, I am glad to say, and here he fluttered along under the eaves. He settled with a beating of wings to hold him in position, then fluttered on again. I watched him settle again and again, probing into the stack. At last he lifted clear into the air, rose with a magnificent swoop, and dropped to settle on the ridge of the rick, where I could see him with head down tearing at his catch. His meal did not take long, and he was soon back again, beating the side of the stack with his wings while he probed with his head. I could imagine the sight of his large eyes and strong, curved beak to some frightened birdikin or mouse. It may have been mice that he was hunting, but I think it was small birds.

And so, as the winter passes, the flocks are thinned by owls, hawks and hard weather, and with the return of spring the survivors are about as many as the generation of their own parents. The winter communities are broken up when every bird finds his mate and builds a nest, and sets about the all-important-seeming business of rearing a family.

A Drinker of Blood

Anyone who has seen a rabbit chased by a stoat, or a field-mouse chased by a weasel, must have had his imagination stirred by the evidence in the hunted animal of such extreme terror. This is the same kind of fear which we sometimes experience in dreams, when our limbs are too heavy to move and we are *unable* to save ourselves. A rabbit, hunted by men or dogs, will run for its life, and run swiftly with a very good chance of escape, but a rabbit that is hunted by a stoat will go hunching and limping, as though the paralysis of fear were cramping all its muscles, and at the same time as it limps along it gives pitiful cries of distress. The chase is a short one, for very soon the rabbit will crouch down in a despair of panic to await the swift coming of its pursuer, and while it endures these last dreadful moments of its life it screams continually. The hunted mouse behaves in very much the same way. If it is chased by dog or cat, it will run with instinctive good-sense and swiftness, and even when captured and maimed by a cat still continues to try to escape, and very often does escape, but if it is followed by a weasel, it becomes a ball of hunched limping misery with every hair on end. It goes as one palsied, and cries out in terror as it goes.

What is the cause, we may well ask, of this peculiar behaviour? I have heard it said that the mouse is hypnotised by the weasel, and that the rabbit is hypnotised by the stoat, but does that really explain anything, unless we can postulate some manner and process of working for the influence from one animal to the other? We must ask how is this hypnotism effected. As the word is usually used, it is meant to connote working of the will. In this sense it can hardly have a meaning in the case of such an animal as the weasel. It also suggests a numbing or controlling of the feelings in the creature which is hypnotised, and this numbing and controlling does appear to be present in the rabbit; but what we must still ask is the nature of the influence producing such an effect, and how does it function?

I have not yet in my reading, or in discussion with other people, found any satisfactory explanation, and so far, as there has been little scientific investigation into phenomena of this kind, one can but look closely at the facts, and then for one's own personal interest and perhaps further advancement, make surmises as to a possible explanation. The main fact is as follows: Certain animals in certain circumstances, act in a definite way, as though by instinct, to the detriment of their own, and to the advantage of some other species.

Every countryman knows what disturbance a fox or a cat can make, by its mere presence, amongst blackbirds, thrushes and jays. A cat has but to walk along the bottom of a hedge in springtime, and a dozen or more birds will be scolding at it. An owl has but to appear openly in the daylight, and all the birds in the neighbourhood will gather round to scream and scold. Here we have an obvious antagonism showing itself in a simple and irrational manner. A weasel has much the same effect on the behaviour of small birds such as finches, linnets, etc., but with this difference. The cat or the owl, when mobbed and scolded at, will take very little notice, and will not use this power that it has of exciting enmity for luring its victims within striking range. If a bird in the frenzy of its indignation is foolish enough to come too close to a cat, no doubt that cat will catch it if the opportunity is good enough, but it makes no deliberate gesture which entices the bird nearer. The weasel in contrast to the cat, deliberately evokes in the small birds an even greater excitement than their original hostility has produced, and at the same time it, itself, will become very excited. It performs a kind of dance of invitation; sometimes it will move quickly round and round, and sometimes will remain comparatively still, chattering and quivering. While it does this, the small birds that are near enough to be within the circle of its charm, flutter nearer and nearer, becoming ever more excited and scolding louder than ever. Nearer and nearer they come until one of them is close enough to be pounced upon and killed.

The weasel has a power over the birds, making them behave in a way detrimental to their interests, but this power when exercised against a mouse seems to be far more potent, and to have upon the mouse quite a different effect. The birds become excited and aggressively angry, they do not show the panic of the mouse, who is obviously trying to escape, but whose limbs fail him.

I have said the mouse is obviously trying to escape, but is what is obvious always what is really happening? If the mouse with all its faculties were trying to escape it would run fast enough. If the birds wanted with all their faculties to avoid the weasel, they would not go nearer to it. The fact of the paralysis and the palsy of fear suggests conflict in the mouse, and are we not justified in asking: Are not part of his instinctive complexes in rebellion? If they were all in harmony with the simple will for life, he would run as he does from a dog or a cat.

We have no definite knowledge of why or how his instincts are in this way perverted, but we are at liberty to surmise, and it seems possible that the fact that the weasel and the stoat are both drinkers of blood may have something to do with this peculiar behaviour of their victims. Is it possible that the blood, which has always been considered as the vehicle of the life, may be, in some way which is at present quite unknown to us, under the influence of the creature which thirsts for it, and that 'the blood which is the life' responds to the stoat or the weasel, even while within the veins of the victims, thus destroying the normal integrity of the instinctive complex for self-preservation? Such an idea is put out as a suggestion, and though it may seem extravagant at first contact, it will not appear so unlikely to anyone who has had the opportunity of closely observing a rabbit and a stoat, or a mouse and a weasel, when associated in their instinctive relationship.

I have myself had several such opportunities, or rather I should say partial opportunities, for one can seldom see the whole drama, but only a part, for on most occasions the stoat or weasel is frightened away by the near presence of a man. Only recently was I able to see at close quarters the actual killing, the behaviour of hunter and victim.

I was in Wiltshire near Swallowcliffe, and was following a foot-track along the downs one misty October morning. The mist was blowing past in soft, cloudy waves, depositing fine drops of water on every small hair of wool on my coat. It grew so thick that I could only see my way by keeping close to the wooden posts that formed the fence on one side of the track; these emerged ghostly grey figures out of the whiteness, and it seemed that the extreme stillness of the heavens had descended with the cloud, and held the earth spell-bound. There were no notes of birds, and no sound was born upward from the distant and invisible valleys—only the tread of my feet on the turf.

Suddenly I heard the characteristic and peculiar cry of a stoated rabbit. I stood quite still, listening. It came again and nearer, and then from the direction of the wind and blowing mist, there came out of the mist, the bunched, stricken form of the rabbit. It moved in the usual palsied way, with its hair lifted on its back. Its extreme fear gave it the repellent look of an animal stricken with some disease. Within two paces of where I stood it crouched down and began a long, continuous scream.

My first impulse was to save the rabbit's life and frighten off the stoat, for such terror was almost intolerable. Yet here might be an opportunity of finding out something about that mysterious relation that has so much interested me. And why should I interfere in the course of nature which was so much removed from my own course? Why let my personal feeling prevent a possible revelation of a mystery? And why indeed should I feel sentimental about a rabbit? I had often killed rabbits. We most of us live on the flesh of animals that are killed we know not how, and why should not a stoat be allowed to follow unmolested its natural instincts, which are considerably less life-wasting than human ones?

I stood as still as I was able while the rabbit crouched at my feet still screaming. It had not seen me; I am almost sure it had not seen me, although it was staring straight at me. It was not asking to be saved, but had come by chance to that place and was deep in an unconscious and desperate crisis of its inner life. The stoat, which was still invisible to us both, was already claiming its blood, and the rabbit, with its very essence answering that claim, could go no further.

A few seconds later, the stoat came galloping with supple elongated, streak-like motion. It leaped upon the rabbit, putting its short arms about the rabbit's neck, and with a cuddling, almost caressing movement, thrust its face down into the soft fur of the nape.

The rabbit screamed more shrilly and threw back its head to that biting embrace. Its eyes were staring and wide as it gazed directly upwards, and I knew that the stoat's small sharp teeth had reached the spinal life, and that the rabbit was now paralysed, and could not, even if its fear were removed, make any further effort.

The stoat, which had climbed on to the rabbit's back, was no longer biting but drinking the blood. The muscles of the neck swelled and contracted, and so also did the muscles of the lean sides. As the rabbit in its terror had not seen me, so also the stoat was completely taken up with the business of drinking. The two creatures seemed mutually involved in that direct communion and transfusion of blood. The joy of killing and the anguish of death were here equated, and as my wonder grew as I watched, it seemed that this union and communion in life and death was a thing having a significance in nature, and was purposed in that intricate and baffling pattern of things as they appear, and that the incapacity of the rabbit to escape, and all its limping, clumsy panic served a purpose which transcended both the rabbit and the stoat. What that purpose is I do not presume to guess, but the more I look at animals and study their ways, with what I hope is an unprejudiced mind, the more it appears to me that they are not contained wholly within their skins, but involve or are involved with forces of which we have as yet but little understanding.

The stoat was still drinking. Occasionally he moved his position to get better purchase, but his face was hidden in the hollow behind the rabbit's ears. These, as the draught continued, drooped and fell sideways. Then at last the head swayed forward, and the wide-stretched eye-lids relaxed.

Very soon after the rabbit was dead, the stoat's passionate nuzzling changed to a sleek and more complaisant satisfaction. He withdrew his mouth from the wound, and lay for a short time on the body of his kill, but soon he returned again for another draught of the fresh blood.

At last he was satisfied, and, withdrawing his muzzle, looked round. His sense of awareness which had been lost during that period of concentration, returned, and looking up he saw me. His black, beady eyes were charged with a quick hostility, and he gave me such a look as a man might have given, if suddenly he were aware that some stranger had been present during the performance of some intimate rite. He drew back his lips and showed his teeth, then moved away from the body and stood looking at me. He chattered and quivered, and I should have very much have liked to know what he was saying. Then with a swift unhaste, he turned and vanished into the mist.

Master Builders

In the twelfth century, wild beavers were still to be found living in Scotland and Wales. A century earlier they were inhabiting many English rivers, and their range was over the greater part of Europe, and extended even as far as the Euphrates. At the present day they survive only in America and Siberia and in one or two out-of-the-way localities in Europe. They are rapidly becoming scarcer, and are threatened by extinction as the result of the trade in their furs.

The most obvious thing about a beaver is his tail. The tail is nearly flat, it is broad and straight and covered with horny scales of a lustrous black. Its principal uses are to elevate or depress the upper portion of the body while the animal is swimming, or to turn it from right or left. While the beaver is swimming on the surface of the water, the tail drags inactive behind, but if, when he is alarmed, he wants to dive, he flicks it up into the air, and so lowers his head, and as he goes into the deeps, he can bring it down with a smack on the surface, which can throw spray two feet into the air, and which makes such a ringing report that all other beavers in the neighbourhood are warned of danger. Mr. Lewis H. Morgan, who has written a most detailed history of these animals, has described this warning sound as being as loud as a pistol shot. It is often followed by several other pistol shots as other beavers follow suit, and as they dive, bring their tails whacking down into the water. This tail is ten inches long by five and a half broad in a full-grown beaver of forty-two inches long, and it is used, when swimming under water, in the same way as an oar is used when propelling a boat from the stern. A beaver is a good swimmer under water and can hold his breath for nearly fifteen minutes. When on the surface he swims with his hind legs only; his back feet are webbed, thus giving him a good hold on the water; his fore feet are small with long claws, and are not used in swimming, but are laid close against the under surface of the body.

A beaver, which is in general appearance like a large water-vole, has small, insignificant eyes, and is short-sighted. This no doubt is due to his living so much in the dark. His sense of smell and his hearing are very acute; he is a shy, night-living animal, and is seldom seen in the day time. His fore feet, which might almost be called hands, are used for the carrying and manipulating of sticks and stones and pieces of earth; it is with them that he does the greater part of the building of his dams.

The dams are engineering feats undertaken on no small scale. The European beaver does not make dams, but lives very much as the musk rat does, in underground passages whose openings are in river banks beneath the surface of the water. The American beaver has, however, abandoned this simple form of life, and makes dams to form artificial ponds in which he may disport himself and find protection from his enemies, and on whose banks he builds domed fortresses of earth and sticks, where he may winter in safety. These dams are not essential to his existence, and it is a remarkable fact that he should have changed his mode of living from the simple to the artificial.

The building of the dam starts in a small way; sticks are cut and collected and laid horizontally across a stream, and mud and fibrous earth are plastered on the upper or water-side of them. As the dam rises in height, the water is held back, and spreads out on either side. The dam has to be both heightened and broadened, and as the water will run more swiftly at one place than at another, the beavers, in answering to this accidental irregularity, will make their dam curved in one direction or another. Larger sticks are used as the dam becomes larger; these are placed in oblique, slanting positions on the lower side of the structure. On the other side large stones are sometimes placed in amongst the mud to strengthen the base, and more fibrous earth is constantly added. In course of time the dam may stretch to as much as three hundred feet in width, and be from six to eight feet in height. These large dams are probably of great age, hundreds or even thousands of years old, having been kept in repair by countless generations of beavers. The weight of water in such a dam is very considerable, and to counterbalance this the beavers appear to have hit on a very cunning device. They build a lower dam a little below the upper one, this catches the overflow and makes a smaller pond further down the stream. The water in this lower pond rises and covers the base of the upper dam, and so offers a weight of water, pressing against the lower side, to counterbalance in part the downward pressure from the upper pond. This is a device worthy of an intelligent engineer. The lower pond, it should be noted, is too small to be of any other use to the beavers, and they do not build their lodges round it.

Another kind of dam is sometimes made higher up the valley above the main pond. This is only made when a large amount of water is liable to come rushing down after rainfall and so threaten the main dam. This upper, sheltering dam is raised a foot or more above water-level so as to be able to carry a sudden influx of water.

The water in the main pond is always level with the rim of the dam, and the chief function of the dam is to regulate the depth of water in the pond, and to keep it about two feet above the entrance of the lodges. The earth at the rim of the dam is constantly liable to be displaced, and is as constantly in need of repair. Every night the beavers inspect it and make good the damage which has occurred during the day. They work in a most regular and conscientious manner, and if an artificial breach is made will repair it as soon as they are able.

The trappers engaged in the fur trade make use of this industrious habit of these humble little builders. They make a breach in the dam, and then set their spring gins under water in the place where the beavers are likely to put their feet when they come to repair the dam. The traps are fastened to a slanting stake in such a manner that should the beaver be caught by the hind foot, and should he dive, which is his instinct, he will not be able to rise again, but will miserably drown in his efforts to free himself. Should he be caught by the fore foot, then his heavy weight and the wrenching power he can exert is liable to break the thin bones of the wrist. By twisting round and round he can sever the skin, and is able to tear out the sinews of the arm, leaving them and his claws and skin of the hand behind in the trap, and so go free. This is the experience, and the comparatively fortunate experience, of hundreds of beavers trapped each year. It affords but an insignificant fraction of the suffering that the fur trade inflicts on animals.

Mr. Lewis Morgan in his book, *The American Beaver and his Work*, deplores the way in which the beavers are being exterminated by the trappers. Like any man who has watched and come to know these fascinating animals, he has a love and a respect for them, and hates to see their pleasant humble virtues, their industry and their love of family, being taken ruthless advantage of, yet he has no false animosity towards the trappers, who are no worse than other men. The trappers follow their trade, and will provide the market so long as there is demand.

The American beaver not only builds dams, but on the shores of his artificial ponds he places his huts or lodges, which offer him protection against any of his enemies, with the exception of man. These lodges are placed half in, half out of water, with two entrance holes, usually from ten to seven feet long, which open under water. One of these is used as an everyday entrance for the beaver and his family, this entrance is usually winding or curved and is about fifteen inches across. The other entrance, which is straight, is used for the introduction of pieces of wood into the lodge. The lodge is a flat, dome-shaped building with walls four to five feet thick, made of earth, mud and sticks. The inner measurements are roughly seven by eight feet across and one foot four inches in height. In these safe places of retreat the beaver family spends the winter; they do not hibernate, but go to and fro to bring wood from their underwater store.

Round each pond there are not usually more than two or three lodges. A dam is started by one pair of beavers; another pair may come and join them as the dam grows. They build their lodges and raise their families, four or five at a birth. They all work at the dam and at the other work of tree-felling, stick-cutting and canal-making, and the storing of winter provisions.

The chief food of the beaver is the bark of trees, not the thick bark of the stem, but the green bark of the branches. In the summer they also eat the leaves and stems of herbs, and are particularly fond of the rhizomes of water-lilies. In the winter they live almost entirely on bark. They will cut down trees with their strong cutting teeth, and will drag or float the branches to their pond, and will there store them under water, on the floor of the pond close to their lodge. How they get the wood to sink and to remain sunk is unexplained, but there is no doubt that they make these underwater stores.

In the neighbourhood of a pond which has for many years been inhabited by beavers, the trees of the right size and kind have been felled. The beavers have to go far afield for their wood. They find it heavy to drag over the ground, and so they will make canals where water can flow from the pond to the plantations. Up these canals, which are three feet wide, they will float wood for their winter store.

Besides appearing to have such a high order of intelligence, or being, if you prefer, so wisely inspired by instinct, the beaver is a pleasant and friendly animal in himself, and is often kept as a pet by Indians or trappers. He seldom bites and is a safe companion for children. His cry when hurt resembles that of a young baby, and even the trained ears of human mothers can be deceived by the calling of a young beaver. For the sake of his fur this remarkable and charming creature is being made ever scarcer. And it seems a pity, to put it mildly, that whole families of these master builders should be killed by such ruthless methods as the following.

The trapper can find by tapping on the ice where the winter store of wood is hidden. He surrounds this with a ring of stakes, leaving one place open. He fixes a contrivance which will tell him when a beaver enters through this one place. Then he sits and watches. As soon as a beaver has entered the palisade, the trapper blocks the exit. The beaver, unable to return, drowns under the ice. The palisade is again opened, and the female beaver comes to see what has happened to her mate. She also is drowned in the same manner. The young beavers follow and all meet the same fate. When they are all dead, the trapper breaks the ice and collects their fur-clad bodies.

An Ambiguous Birth

Most of the sheep-farmers of North-west Australia tell the same story about the birth of the kangaroo. These men are for the most part good observers of their surroundings and of the creatures with which their work brings them into contact. They know the trails and habits of the reptiles, birds and mammals which find a living on the arid, semi-desert plateaus of the North West. As field naturalists they are not to be despised, and I have again and again found how penetrating and accurate their observations have been. But the story they told, and it was always the same story, about the birth of the kangaroo left me sceptical. Not till the proof was presented to my unbelieving eyes, would I believe there was anything in it, and even then I was sceptical. I had been taught otherwise, I knew that the kangaroo, like other mammals, had a uterus, indeed I knew that she had two, and that although the young kangaroo was born, like other marsupials, at an early stage, yet I knew that the young were born out of the mother's body as other mammals are born, and that they were certainly not budded from the mother's abdomen, as these men maintained that they were budded, and as indeed the sight of the dead mother kangaroo with the yet living young ones would persuade my unwilling reason to believe that they were budded like so many young polyps on a stem. Without a doubt they were attached to their mother's body within the pouch. The flesh was continuous between their heads and the skin of the maternal abdomen. It was impossible to pull them off. They were indeed as the sheep-farmers had told me, like buds. And when one of the unhappy youngsters was pulled off, the tissues broke revealing the torn blood-vessels which went between the mother and the young. There was no separation here, and no wonder that anyone should suppose that the young creatures had been budded out, as my informants had told me.

On looking more closely at the young kangaroos, which in this case were not more than two inches long, one could see that the lips were enormously swollen, and it was through these enlarged lips that the young creature was fastened to the mother's body, that the blood-vessels passed. They formed in fact a kind of post-natal placenta.

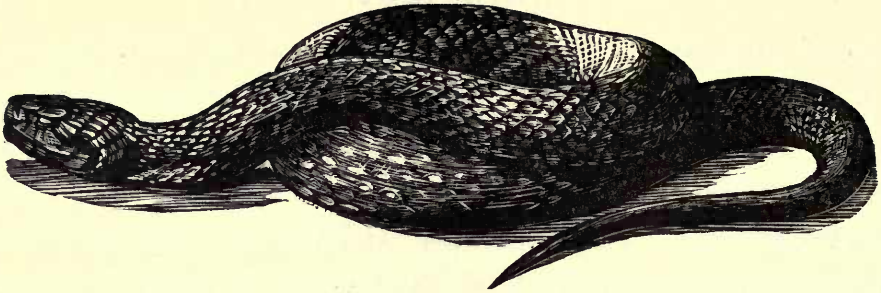
In spite of the fact of this attachment through the lips, my sheep-farming informants had in this case been at fault. The young kangaroo is not budded in the mother's pouch, as they believe, but is born in the ordinary way; it is born at a very much earlier stage than the young of the placental mammals. When the young kangaroo first leaves the mother's body, it is scarcely more than an inch long. It is in a very early stage of development, but it has enormously developed prehensile lips.

After it has been born, and while it still lies helpless on the ground, the mother kangaroo picks it up with her lips, and places it in the pouch, on one of the sebaceous glands which later function as milk glands. The young animal fastens on, and in a short time the skin breaks down between mother and offspring, and there is established a second intimate relationship in which the blood of the parent brings nourishment to the young. For several months this state of attachment continues, and no doubt it was during such periods, when the young and the mother were of one continuous flesh, that the Australian farmers and bushmen had made their observations. The young kangaroos *appeared* to be budded from the maternal abdomen, and nothing that I could say would shake them from their belief.

As the weeks pass, and the young kangaroos grow in strength and size, the lips become comparatively less large and after a time an abscess layer is formed, and the tissue which connects the parent and the young breaks down. A new stage of life now develops, and after this second separation from the parent, the young kangaroo lives by the sucking of milk from the mammary glands. All this time of course it lives in the pouch, and remains a frequenter of the pouch long after the time when it can leap in and out, and partake of adult food. It is astonishing indeed to see how large the young kangaroo can be before adopting a completely independent life.

This method of birth, observed and recorded in the case of the kangaroo and wallaby, is probably repeated in all other marsupials. I have often seen marsupial mice and bandicoots with young in their pouches, but the young have always happened to be in the later stages of their development. I have never seen them in the 'bud' stage. They must be extremely minute, if the newly-born kangaroo, a creature which stands five feet high when mature, is barely an inch long. How much smaller must be the newly-born mice?

The parallel developments within the marsupials and the placentate mammals is a phenomenon which must strike any observer as remarkable. Here are two quite different groups of animals which have not only essential differences in the manner of birth, but also in the formation of their bones. It is probable that the marsupials mark an earlier stage of evolution and that they have been replaced by the placentate mammals in most localities. The marsupials are still found in Australia, Tasmania and South America, where they appear to have been protected from the competition of the more lately evolved forms. It is indeed remarkable that both groups of animals are divided into sub-groups which show marked parallel resemblances. Among the marsupials there are the kangaroos and wallabies, which are herb-eaters and show a marked resemblance to the ungulates; there is the Tasmanian wolf, showing a marked correspondence with the carnivores; there are the marsupial mice and rats, which in outward appearance are so similar to the rodents as to be hardly distinguishable, when they are running wild, from the placental mice and rats, and there are insect-eating creatures, such as bandicoots, which present a parallel resemblance to such insect-eaters as the hedgehog. Is it not an extraordinary fact that the same kind of outward forms, the same habits of life should distinguish corresponding groups within these larger groups which have been evolved or created at separate times and quite distinct from one another? Does this not suggest that the same final cause, or some similar factors of the same final cause, was determining these parallel lines of development?



Vitality in Snakes

One of the most vivid recollections of my childhood is of a drive through the Tasmanian bush on the way to church. My mother and myself were on a visit to relatives who had a large farm near Laucheston. Church-going was an important event, never to be missed, and the whole household turned out in two buggies for the five-mile drive through the bush. I was on the back seat of the second buggy with two other children. Tim Watson, my cousin, who must have been about twenty at the time, was driving, and my mother was sitting beside him. When we had gone the greater part of the way, my mother, who was always quick at seeing wild things in the bush, saw a large, black snake which was lying sunning itself near the track. Black snakes are poisonous and are regarded by all true bushmen as the enemies of mankind. My cousin dropped the reins and jumped down with his whip, and began striking at the snake, which at first tried to make off, but very soon turned to defend itself. We children on the back seat soon tumbled off, and, picking up what sticks we could lay hands on, tried to help.

My mother had all she could do to control the horse who became infected by the general excitement.

The contest lasted a good five minutes before the snake's back was broken. Tim managed to get a forked stick across the back of its head and then drove the blade of his pocket knife through the base of its skull. But the snake was by no means dead. Tim said it was not possible to kill snakes completely, and as this was an exceptionally large specimen, and he did not want to spoil the skin by knocking it about, he pinned its head to the bottom-boards of the buggy. We drove on to church with the stimulating feeling of the snake's coils writhing every now and then about our ankles.

After the service all the congregation and the parson came to see the snake which appeared as active as ever, though its head was still pinned to the boards of the buggy. The general opinion was that this was the largest black snake that had ever been killed in the district. We were very pleased and proud of ourselves and, after dinner, we children turned out to help with the skinning.

I remember the thrill of awe and revulsion which I felt when I was shown the fangs, with their inflated bags of poison at the base. Tim squeezed the poison out for us to see. Then came the skinning and the second and the third thrill. The flesh was astonishingly white, with a queer iridescence in the muscles which moved in rhythmical convulsions as the skin was peeled from them. I have later seen exactly the same movement, though even more pronounced, in the flesh of a turtle. Steaks of turtle flesh, I have seen move themselves from place to place by this rhythmical convulsion. The other thrill was afforded by the undigested or partially digested animals which came out of its stomach. Two complete kangaroo rats and a partially digested chicken. This latter surprised us for it was not of a breed that could be identified on any of the neighbouring farms.

At last the skin was clear of the carcass, and the white-fleshed and still-moving body was thrown on to the rubbish heap. The next morning I went back, fascinated, to look at it, and was relieved to see that it was at last properly dead with no lingering signs of vitality.

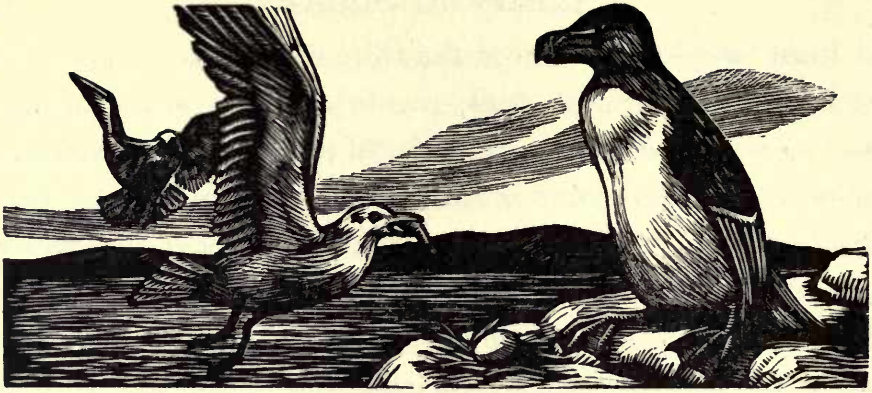
And yet, strange, almost incredible to relate, there was a part of the snake which still harboured some remnant of life, which was to endure for many years to come.

The skin, when it was peeled off, was stretched and nailed to a plank, inner side uppermost. This was dusted with pepper and salt and then painted with arsenical soap and left to dry in the sun. It measured nearly eight feet, and was considered worthy of being subsequently sent to a taxidermist in Hobart to be mounted on green baize, and was then given to my mother as a memento of her visit to Tasmania. It travelled back to England with us, and for many years hung on the wall of our dining-room. I cannot say for sure how long we kept it, or what ultimately happened to it, but I know that we had it for ten years at least, and all that time it gave a seasonal affirmation of its undying vitality.

Every year it shed a thin, gauze-like skin of outer scales.

It is well known that snakes shed their skins each spring, and most people have found the thin, dry, brown fabric of the cast skin caught amidst thick grasses or amongst briars, but it is not so well known that the skin of a snake, even though detached from its body and mounted on a cloth and hung up in a sitting-room, will also make an effort to repeat this seasonal change year after year at the appropriate time. Thin, very thin, flake-like scales are formed on every scale of the skin, even those over the eye-scales are formed, and these, each year have to be dusted off, if the skin is not going to look too disgracefully shabby.

What sort of life is this which continues far away from and quite independent of the main part of the body of the creature? What is the life which persists in this mere portion? How can it survive the drying in the sun, the dressing of pepper and salt and the arsenical soap? What is there to nourish it? From where can it gain its impulse towards this divesting itself of that which would by this time be the old and faded covering, had the animal remained within the normal rhythm of its existence? Can this activity be a mere chemico-physical reaction? And if so, to what? What is life? Biologists and philosophers of all periods have offered various suggestions, and psychologists tell us in general terms that life is a state of equilibrium maintained between opposing forces of creation and destruction, and this perhaps is as satisfactory a definition as one can find for what remains unknown and still baffling to the investigations of science. But what, in this case, are the opposing forces? And what is the impulse which urges this detached, and, in all other respects, dead skin, to show this symptom of life?



Sea Birds

There are cliffs in South Devon where razorbills make their nests, or it would be more correct to say, lay their eggs, for they make no nests, but lay their large, various-coloured eggs on the cliff-ledges. In late July and even early August, one may still see the young birds and sometimes the unhatched eggs perched on their craggy nurseries, and the older birds busy with feeding and incubating. At Woody Bay there is a trackway through one of those wind-swept oak woods which cling to the cliff face, which leads down to a good vantage point, from where it is possible to observe the birds without disturbing too much their peace of mind.

The razorbill and its close relative the guillemot are essentially sea-going and sea-living birds, which only visit the land for the breeding season. They incubate only one egg at a time, but when their first nursling is launched into the world, they will come back to the rock-ledge and lay a second egg. The parent birds do not have the appearance of strong fliers, their wings are very short and they have to move them very fast, and when they leave the water, they do so with a great splashing and paddling of the legs. When once fairly in the air, they rise in gradual ascent with a whirring of pinions. On the land they are clumsy walkers, but in the water swim marvellously well, using their short wings as paddles when they dive.

They feed their young on small fishes, and it has always seemed to me a bit of a mystery how they manage to hold so many in their beaks at the same time. I have seen birds with already two or three fish in their beaks continue diving for more, and ultimately come up with five or six live fish. How is it that they manage to get more fish in, without letting go of those which they have already caught? But manage it they do, and arrive at regular intervals with their beaks stuffed full of wriggling fishlets. Seldom do they let any escape, except when attacked on their way to the nursery by the thieving gulls, and then it is an amusing sight to see how the gulls dive down and swoop and catch the falling fish in the air before it can touch the sea.

When I have been watching the razorbills with their young, I have wondered how the young birds get from their high ledges of rock, often eighty or a hundred feet above the sea, down to the water. They certainly cannot fly there, and if they were just to lurch over the edge, they would in many cases fall on to rocks and inevitably be killed. The Devon fishermen tell me that they have seen the young birds carried on the backs of their mothers, and this I think must be the case. I have waited long hoping to see this sight, but never has my patience been rewarded. It would be a remarkable sight, and a feat which would demand a good deal of skill, for the young bird is a considerable size at the time it takes to the water, and would be no light burden for a bird with such short wings. And how is it to keep hold on the sleek, downy back of its mother?

While waiting to see the descent of the young razorbills, I have watched the gulls exhibiting their supreme mastery of the art of flight. There is a wonder and fascination in watching them. They can at times appear to remain quite motionless in the air, and will hang stationary, with their wide yellow eyes fixed on me, then, with the least inclination of a wing, will swoop and fall and be a hundred yards distant in what seems but a second of time. They are as much creatures of the air as the razorbills are creatures of the water, and yet they are very much at home on the sea also, and like flecks of foam float and toss between the waves. When they are flying they often seem to be dreaming in their flight, and if seen far enough off, appear quite forgetful of the earth, but at a closer view their yellow eyes are filled with hungry intelligence, continually on the look-out for something to eat. They are as greedy and rapacious as the strong hooked beak and the low forehead which supports it would lead one to suppose.

Among the talus of tumbled rocks near the cliff base there are usually rock-pipits flitting to and fro amongst the boulders. As the warm August afternoon passes, they seem to bear a resemblance in their wayward movements to one's lighter fancies, which are pleasantly doing something, nothing very important, but sufficient, as they flit for hour after hour in and out amongst the rocks. Only occasionally one or other makes a flight into the upper air, and then almost invariably it is attacked at once by one of the gulls. I have seen them caught and eaten, but usually they escape. They are small and can dodge quicker than the gulls, and make sharper turns. As a butterfly can usually escape from a sparrow, so do the pipits escape from the gulls; they dart back to the shelter of their familiar rocks, and as soon as they are near them once more, the gulls give up the pursuit, and in a few seconds they have forgotten their danger and are back at their games amongst the boulders as though nothing had happened.

One of the most remarkable of sea birds is the storm petrel. These small, frail-looking birds, which look like long-winged house-martins, can be met far out in the Atlantic, where there are few if any other birds. They have a habit of following ships, not, I believe, as gulls do to pick up the scraps which are thrown overboard, but to catch the sea creatures, which are churned up by the passing of the ship. I have watched one or two of these little birds following for day after day in the wake of the ship in which I have been travelling. They seem always to be on the wing, and never have I seen them resting on the water, though I think there must be times when they pause and rest. They fly very close to the waves, just skimming them, and often they paddle with a quick motion with their webbed feet as they fly. This characteristic action has won for them the name of 'Little Peters' trying to walk on the waves. It is a small sooty bird with a white patch above and below the base of the tail. In the storm petrel the tail is square and not forked as in some allied species. The flight is strong and erratic, much resembling a swallow's, and with the same assurance as a swallow it flies close to the water, and can catch, as it flies, without alighting, small fragments from the surface and scoop up any oily matter. I have never been fortunate enough to see these birds swimming, but I am told that they swim when the waves are too rough for them to fly over them easily. Then it is they will sometimes rest themselves in this way. But they rest very little, and watching them day after day and hour after hour one wonders, do these and other sea birds ever sleep? Gulls I have seen with eyes closed, floating on the waves, taking what may be momentary naps, but petrels seem ever-restless and ever-tireless.

Another bird which would appear to be possessed of an almost infinite energy is the albatross. I have watched an albatross all the way from The Cape to Australia. He followed our ship floating in the air in the easiest manner at about fourteen knots an hour. At this pace he did not seem to move in any way that could be considered a deliberate form of flight. He just stayed there, suspended in the air and travelled with us. If it should happen that his attention was caught by some object on the sea, he would slope his great wings, and be away a quarter-mile distant, and with the next movement, turn and be back again, and in his place above the mast, watching; or he would drop to the water, and would be left behind while engaged in the business of eating some fragment thrown overboard from the galley, and then with an easy and marvellous speed overtake us again. All night he would fly close beside us, the white expanse of his wings like a ghost in the darkness, and the next morning would be in his place, flying with the same untiring ease and little movement. I do not think he slept. Or did he perhaps sleep as he flew?

That Sea Beast

That sea beast
Leviathan, which God of all his works
Created hugest that swims the ocean stream.
Paradise Lost.

The whale, and let us take the noblest of its kind, the cachalot, is the largest living animal. A full-grown sperm whale can be from eighty to ninety feet in length, and nearly forty feet in fullest circumference. A specimen of this size would weigh about ninety tons, and would considerably out-weigh the combined population of a whole village of one thousand one hundred inhabitants. This enormous creature is no fish, although living entirely in the sea. It is a warm-blooded, air-breathing mammal, and it is supposed that his early, ancestral forms had their origins on the land, and gradually became adapted to a marine life. Vestigial hind-limb girdles are found embedded in the flesh; the fore-limbs are, of course, represented by the swimming flippers.

The whole body of the whale is covered, as with a skin, by blubber, which is something of the consistency of firm, close-grained beef, but tougher, more elastic and compact, and ranges from eight or ten to fifteen inches in thickness. It is from this blubber that the oil is extracted. A large whale will yield from this blanket of blubber close on a hundred barrels, and it is by reason of this close blanketing of the body that the whale is enabled to keep himself comfortable in all weathers in all seas; by this his warm blood is kept at an even temperature. On the outer surface of the blubber there is a thin, transparent substance, covering the whole body, this is as soft as satin and as flexible. It can be scraped off, and when dried still retains its transparent quality, though it becomes, as it dries, hard and brittle.

The whale's head occupies a full third of the body's length. The eyes are set far back and low down near to the angle of the jaw. They are comparatively small for so vast a head, and are no larger than a horse's eyes, and are without lashes. They are set one on each side with all the bulk of the head between them, and it is plain from their position that the whale cannot see what is ahead of him, nor what is behind him. Their position corresponds to that of a man's ears, and if we imagine what the world would look like if our eyes were in our ears, then we may get an idea of how things may appear to a whale. A whale must have two fields of vision which are both quite different; he must have the power to look at two different things at once. This must be either perplexing, or else he must have a mental power more comprehensive and subtle than man's, which enables him to turn his attention on two distinct prospects, one on one side of him, and the other in an exactly opposite direction. The ear is so small that it is extremely difficult to see. There is no external leaf, only a tiny hole which is situated a little behind the eye. The whale is dumb, and can make no sound save the rasping of his breath through the spiracle. He has no nose, and his spout-hole, which is his outward breathing organ is at the top of his head. There is no direct connection between the windpipe and the mouth, and on this account he can stay with his mouth open under water without fear of water getting into his breathing organs. Sometimes the cachalot can be seen through clear water hanging supine with his lower jaw dropped at right angles to his body, and mouth wide open. The jaw which is placed completely under the head is, in a large whale, fifteen feet long with forty-two teeth in it. This view of the gaping mouth must be truly appalling. The front of the whale's face is quite featureless, it is a dead, blind wall without a single organ or prominence of any sort whatever. This upper portion of the head is encased in blubber like the rest of the body, but here, though not so thick it is of harder, tougher nature; it is so tough and hard, though boneless, that the 'sharpest lance darted from the strongest human arm impotently rebounds from it. It is as though the forehead of the sperm whale is paved with horses' hoofs'. Behind this blank, featureless forehead is a great unctuous mass wholly free from any bony structure. The lower part is an immense honeycomb of oil formed by the crossing and recrossing of tough, elastic, white fibres; the upper part, known as the *case*, is a great tank of spermaceti, which in the living whale is a pure, limpid liquid. This case covers the entire length of the head, some twenty feet or more.

Behind this enormous oil tank in the forehead is the brain, contained in a comparatively small cavity in the skull. Compared with the huge bulk of the whale, the brain is small, but it is by no means small in itself. It is considerably larger than a man's brain. Physiologists tell us that the size of a brain determines the intelligence—size and the amount of convolutions which exist in the surface folds. A whale's brain is even more deeply convoluted than a man's, so that both by size and convolutions the brain of the cachalot would indicate a high state of intelligence. Professor Adam Sedgwick when he lectured on the whale would never pass over these points. 'Had the whale', he used to say, 'a means of recording his experience, then he would have been the master of the world. Possessing a better brain than man, bigger, more convoluted, he lacks only the reversible digit, the thumb which can grasp and hold a tool.' Had the whale but the reversible digit, then such a civilization would have arisen from the sea as would be beyond the dreams of puny man. . . . But perhaps not . . . perhaps the greater intelligence of the whale is of a Buddhistic or Yogi-like nature, and the vast monster, when he is seen submerged and stationary, with his jaw drooping and mouth agape, may be then deep sunk in meditation, with all his bound-up and mute imaginings made calm and still, and the immense vigour and vital strength of him lulled into harmony with the peace which is eternal. What visions of the soul's profundity may then be his?

Herman Melville, who comes as near to knowing the whale in a sympathetic and imaginative manner as any man has done, describes a scene off Java Head, when a whaling ship came in contact with a vast herd of sperm whales. The three boats were lowered and started on their work of slaughter. One of the boats was dragged by a harpooned whale into the heart of the shoal. Here the hunted whale made his escape from the iron, and the men, awed by the number of whales, which were on all sides of them, held their hands from further attack. Melville describes how like household dogs the whales came snuffing round them, right up to the gunwales, and touching them; till it almost seemed as though some spell had suddenly domesticated them. And he continues:

'But far beneath this wondrous world upon the surface, another and still stranger world met our eyes as we gazed over the side. For, suspended in those watery vaults, floated the forms of the nursing mothers of the whales, and those that by their enormous girth seemed shortly to become mothers. . . . and as human infants while suckling will calmly and fixedly gaze away from the breast, as if leading two different lives at the time; and while yet drawing mortal nourishment, be still spiritually feasting upon some unearthly reminiscence; even so did the young of these whales seem looking up towards us, but not at us, as if we were but a bit of gulfweed in their new-born sight. Floating on their sides, the mothers also seemed quietly eyeing us. One of these little infants, that from certain queer tokens seemed hardly a day old, might have measured some fourteen feet in length, and some six feet in girth. He was a little frisky; though his body seemed scarce yet recovered from that irksome position it had so lately occupied in the maternal reticule; where, tail to head, and all ready for the final spring, the unborn whale lies bent like a Tartar's bow. The delicate side-fins, and the palms of his flukes, still freshly retained the plaited crumpled appearance of a baby's ears newly arrived from foreign parts.'

If a seaman, whose business amongst the whales was but to hunt and kill, could see thus much, and paint so charming a picture, what might not a naturalist, or an educationalist, or even a psychologist—what might he not learn of these monsters of the deep, if once he could establish communication with the intelligences which are possessed of those highly convoluted brains, and whose vast bodies lack but the reversible digit to be masters of creation?

W.N.H.

Hands and Tools

Most of the preceding accounts of life histories have been chosen as presenting cases of complicated adaptation. In these examples where a highly developed instinct, determines the behaviour we see the bodily form as the explicit expression of function, and the animal, together with its activities, making a strictly limited unity within a perfected pattern. When considering such elaborate associations, as for example that of the yucca and the *Pronuba* or that of the sea slug and the coelenterates on which it feeds, we find it hard to imagine, as the older biologists have done, that these highly-specialised and interdependent characteristics are in their present state of interrelationship of form and function, because they have become so either through adaptation to environment or through the action of natural selection, but rather that they have become what they are as the result of inherent final causes. Aristotle has spoken of these final causes as an *entelechy*, which word literally translated means a complete reality or actuality. This entelechy appears in the cases which have been described as an innate wisdom, finding its limits within the morphological, physiological pattern that the animal life-history presents—a wisdom which has penetrated deeply into the organism, and has determined the behaviour of the creature and also its development, for the organs have become what they are in accordance with the *idea* of what the animal is. In this concluding chapter, it will be worth while, for those who have read so far, to compare the human hand and its functions with those highly specialised organs of the instinctive creatures already described and with the functions which these latter perform. From such a comparison it will be seen that a different kind of final cause is here in operation.

First if we compare the human hand with the homologous extremities which take its place among the mammals, we will at once perceive that it is less well equipped for its tasks, or rather for any *one* of the tasks which the animal's extremities have been modified to perform. The paw of a lion or a cat, armed with formidable talons, is better adapted for tearing and holding; the hoof of a horse is better adapted for running, the foot of a mole for digging; the sloth's climbing foot is better adapted to holding to branches, the wing of a bat for flying, and the flipper of a seal for swimming. All these organs are far more highly modified for their purposes than is the human hand, and each is possessed of a perfection which the hand lacks. If then, for the moment, we neglect its latent possibilities, we see that considered as a tool, formed for a particular task, the human hand is more imperfect than are the homologous organs of other creatures. It can also be seen that in its physical form the human hand can be taken as a starting point for all the other modifications. The animal organs can be regarded as tools which have become specialised; only the hand in its unspecialised state includes the potentialities of all these in itself; and this, not because it has been developed beyond all others, but because it had remained behind all others. It has avoided any of the characteristics of finality, any extravagant metamorphosis which would limit its adaptability. Because of this arrested physical development it retains the versatility which enables it to make use of tools, which it can fashion at the instigation of the mind. For the very reason that human hands are so undeveloped, the human mind has been compelled to devise tools to replace the tools which animals have found in their own bodies. To be able to imitate a flipper, man has lengthened his hands into paddles or oars. The hook of a climbing iron is very similar to the curved claw of a sloth. The boat-hook, which man has devised for holding fast, is very similar to the claw on the foot of a bee. Pincers are similar in design and action to the mandibles of insects, and in many other ways, consciously or unconsciously, man has substituted manufactured tools which are equivalent to those which are incorporated in the bodies of animals. An investigation of animal weapons will soon reveal that the greater the perfection of these tools, the more limited is their purpose; the human hand alone remains adaptable to many uses, and this because it is less specialised than any animal limb.

This argument that the human hand is less developed than the extremities of animals is supported by the facts of embryology. If the embryos of a man, a dog, a rabbit, a bat and a bird are observed in their early stages, it can be seen how hand-like the anterior limb is. The mature form only gradually develops from its hand-like origin. The paw and the wing are final stages, perfected tools for running and flight. The hand of man remains nearest to the embryo form, undeveloped and foetal. A stopping short, a retardation is the characteristic, the distinction of the human organ.

The paleontological record, in so far as it is at all complete, demonstrates the same fact, namely that the highly specialised tools of mammals have been developed from an archetypal five-fingered hand. The well known and oft-quoted story of the development of the horse is an illustration of this. The contemporary horse has only the third member of the radial five-toes system to run with. It only uses the abnormally lengthened middle finger. The other radii, as the ancestral chain shows, have gradually degenerated. The primal forms (*Eohippus* and *Hyracotherium*) had the four radial toes still fully developed, and with the fifth hind toe rudimentary. No one of the fore toes was lengthened into a special running limb. The development has here been most obviously away from the archetypal pattern, to which the human hand still bears such close resemblance.

Not only the hands of the human being but the head retains its primitive condition, and its resemblance to the foetal head. The human head stands erect and aloof upon its neck, and does not participate in the physical activities of its possessor, as does the animal's head. The animal's head is invariably used as a tool of some sort or other—the elephant's and the giraffe's for reaching up towards and for plucking food, the whale's for parting the waters, the bull's and the stag's and the goat's for fighting, the beaver's as wielder of its chisel-like teeth, and so on. Even the birds, which have the same upright carriage, and carry their heads erect, use their heads as tools for cleaning their feathers and as weapons for pecking and tearing and for cleaving the air. This instrumental nature of a bird's head is particularly marked in the case of the parrot with its pair of tongs, and in the case of the woodpecker with hammer and axe. Man alone holds his head, reserved and aloof. The modification of the animal's head into a tool, for physical operation on its environment, has taken from it the universality which distinguishes the human head, and what it sacrifices in universality it gains in physical efficiency. The embryo of a chimpanzee and also a young chimpanzee has a skull and a face of human shape, with the features flat in the face, the skull domed and rounded; but as it develops from childhood towards adolescence the crown of the skull is raised into a bony ridge, which joins other ridges at the back which come up from the temples to meet it; the mouth and the lower jaw come forward to form an animal jowl, and the rims of the eye-sockets thicken, and the eyebrows swell in front of a receding forehead. This change from the primitive and foetal condition to that of typical adult animal takes place in the course of five years, a time in which the face of a child has changed very little. The animal's visage has become modified into a tool and a weapon, while the human face has remained very near the archetypal form. The human head does not develop as does the animal's but achieves its significance by keeping its pristine shape.

But what about the brain, which is so far more developed in man than in the animals?

It is both obvious and true that man has a more highly developed brain than any animal, and it has been argued by a Dutch anatomist, L. Blok in *Das Problem der Menschwerdung*, that the brain of man has been able to continue its development further than the brains of animals precisely because it retains its foetal proportions. He demonstrates that the axis of every vertebrate embryo is considerably curved at the cranial extremity, and turned back on itself like the handle of a walking-stick. This curve retains, in man, its characteristic form through out life, and this is the reason, argues Herr Blok, why a man's nose, which is the organ adjoining the olfactory lobes, which are the anterior termination of the brain, points in a direction almost parallel to the axis of his body. In the majority of mammals on the other hand a straightening out of this curve takes place during the later part of the foetal period. The head and brain of the higher animals begin with the characteristic human proportions, but have not retained them. Only the human body is stamped so characteristically with the continuance of the foetal conditions.

From these considerations it would seem that a capacity to hold back from the developments of specialisation, which have been followed by animals, marks man's superiority. Because he has remained nearer to a primal, and perhaps more plastic condition, he is able to follow his way towards that final cause, to use Aristotle's phrase, which conditions his becoming. What this final cause may be, science does not pretend to answer, though the words of religion which speak of 'the foxes having holes and the birds of the air having nests, and the Son of Man having nowhere to lay his head', speaks with no uncertainty of these facts.

The comparison which finally presents itself between such highly specialised creatures as the *Asmidea* or the sea-slugs, and man, who is born helpless into the world, and who has such comparatively weak instincts to guide him, suggests that quite different kinds of life-organisations are here at work. And man after contemplating the lower animals and the exact and limited wisdom which is expressed in their behaviour, and then looking at his own hands, which are soft and unarmed, and fit only for the plucking of fruit or the weaving of leaves or stems, is justified in the thought that in their nakedness and imperfection lies his superiority. He is not, as they are, in bondage to a body already so strictly adapted to conditions. He can say to himself: I am less complete within myself than are the animals, and my body uncovered by any protection, can in no way prophesy what shall be my destiny. In all other creatures I perceive limited capacities, which inevitably accompany their development, for how could the behaviour of the animals be at variance with their form? No wisdom so perfected as theirs has penetrated into my structure. I am without wisdom, but of unlimited capacities.

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